ASSESSING HOSPITAL QUALITY: AN OUTCOME STUDY OF PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN MASSACHUSETTS HOSPITALS

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TABLE OF CONTENTS

Chapter

APPENDIXES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Despite public interest in outcome information that help consumers to make informed choices of their health care providers, little is currently available in Massachusetts although the Commonwealth is known for its hospital industry. Health care outcome measurement is difficult. The problem remains how to measure outcomes and make a fair comparison among providers given differences in patient casemix. Providers are deeply concerned with outcome measurement that may bias their outcome results, and most importantly damage their reputation as quality care providers when the outcome information is made public. In light of the issues surrounding health care outcome measurement and fair comparison of providers, using logistic regression and mortality outcomes of patients with acute myocardial infarction (AMI), this study seeks to answer the following research questions: what are the hospital attributes and process of care variables that are associated with AMI patient outcomes controlling for patient risk factors? Do Medicare and Medicaid patients have the same AMI outcomes as those of private-payer patients? Controlling for patient risk factors and hospital attributes are there significant differences by hospitals and/or health plans in patient mortality?

This study identified a wide range of attributes of structure and process of care associated with AMI patient outcomes and explored the interrelationships between structure of care and process of care, controlling for AMI patient demographic and clinical risk factors. A conceptual framework was developed building on the framework of Medical Outcome Study (MOS) by Tarlov et al and research by others. The source of data was Freedom of Information Practice Act (FIPA) and RSC-403 collected and disseminated by the Division of Health Policy and Finance, a state agency formerly known as Massachusetts Rate Setting Commission. Over 14,000 AMI patients hospitalized during 1995 were included in this study.

Many attributes of structure and process of care were found to be associated with AMI patient mortality outcomes, in particular, those related to hospital characteristics and patient process of care. The most important are: age, type of insurance, diagnosis, tertiary hospitals, AMI patient volume, and invasive procedure use.

Medicaid and Medicare patients were found to have poorer outcomes than private-payer patients, controlling for patient risk/severity, hospital characteristics, and process of care although the finding was statistically insignificant at the 0.05 level for Medicaid patients (p=0.0654). However, Medicaid patients were also found to have significantly less invasive procedure use than private-payer patients while Medicare patients had more use. Less invasive procedure use due to Medicaid insurance coverage (the indirect effect of being a Medicaid patient) was found to be partially responsible for poorer patient outcomes among Medicaid patients. Hospitals were shown to differ in their mortality outcomes. The differences among tertiary hospitals were relatively smaller than those among non-tertiary hospitals. Some community hospitals were measured better than

tertiary hospitals; some worse, controlling for patient characteristics, hospital differences, and patient differences in process of care

Results of this study suggest that the Medicaid and Medicare programs need to continue monitor the quality of care that their beneficiaries receive and intervene when necessary. A reimbursement based on patient outcomes was recommended. More research is need to understand the hospital outcome variations and differences in outcomes and process of care between public and private-payer patients.

CHAPTER I

INTRODUCTION

Purpose of the Study

The health care environment is increasingly demanding quantifiable measurement of clinical outcomes (Lynch, et al., 1993). Purchasers want to know the value of their health care purchases. At present, most Americans know more about buying a pair of sneakers than they know about choosing a physician or a hospital (Rother, 1992). Despite this public interest, outcome measurement is difficult. Providers are deeply concerned about outcome measurement in which differences in patient case mix may bias the results. Misleading outcome measurement may damage a provider's reputation unfairly. Health care researchers and analysts are now seeking answers to the questions about how to measure patient outcomes. They want to know, not simply which providers deliver good or bad care, but what are the attributes that influence the outcomes.

The present study proposes to use acute myocardial infarction (AMI) inpatient mortality in Massachusetts as an example of outcome measurement. AMI mortality has been selected primarily for reasons of data availability: Massachusetts collects and requires hospital discharge data, and AMI inpatient mortality outcome is uniformly reported since mortality is a clinical end point (Annals of Internal Medicine Editorials, 1993). Beyond that, AMI is a public concern because it is a high risk/cost/volume medical condition. A further discussion on AMI can be found in the problem statement later in this chapter.

In light of the issues surrounding health care outcome measurement and fair comparison of providers, this study seeks to answer the following research questions: 1) What are the hospital attributes and process of care variables that are associated with AMI patient mortality controlling for patient risk factors? 2) Controlling for patient risk factors and hospital attributes, are there significant differences by hospitals and/or health plans in AMI patient mortality? 3) Do Medicare and Medicaid patients have the same AMI mortality as those of private-payer patients?

To conduct this study, an analytical and conceptual framework has been developed building on the framework of the Medical Outcome Study (MOS) by Tarlov et al. (1989) and research by others. The MOS provides useful theoretical grounds for monitoring and measuring the results of medical care. It includes three essential components: structure of care; process of care; and outcome of care. Thus, this study will be concerned with investigating the attributes of structure of care and process of care associated with patient outcomes. The study will control for AMI patient demographic and clinical risk factors that influence patient outcomes.

The data sources for the proposed study are Freedom of Information Practice Act (FIPA) records and RSC-403 cost reports. These are collected and disseminated by the Division of Health Policy and Finance, a state agency formerly known as the Massachusetts Rate Setting Commission. Data analysis will include descriptive statistics and econometric modeling.

Significance of the Study

The U.S. health care industry is in crisis - a crisis of accountability (Linder, 1992). Previously, people assumed high quality in the American health care system largely based on the myth of patients' trust in their physicians, hospitals, and health care organizations, as well as advanced medical technology. As awareness has grown concerning health costs and quality, in recent years, government, business, patients and health care professionals have begun to question how physicians, hospitals and health plans provide care to their patients and what the clinical outcomes are for the patients. They want to know how successfully a hospital or a health plan keeps people well and provides needed hospital care when they require hospitalization; and whether patients return home and enjoy a reasonable quality of life after costly hospitalization. These are the questions that also matter most to the patients.

A report by the Institute of Medicine (IOM) on Medicare quality assurance points out that "feedback and data reporting have three primary dimensions: information made available to internal quality assurance programs and practitioners, to the public, and to the policy makers" (Rother, 1991). Outcome information provides incentives to the providers so that those hospital providers who perform well would likely be rewarded for excellent quality practices in the competitive marketplace; those providers who perform poorly would be forced to improve their practices in order to stay in the marketplace. It makes competition work to the best interests of both patients and providers.

Government is greatly affected by this outcome-focused movement because of its key role in the U.S. health care delivery system as the biggest health care purchaser. For example, total HCFA program outlays were $248.9 billion in 1995, 16.4% of the $1,519 billion federal government budget and 3.5% of the $7,180.7 billion gross domestic product (HCFA Statistics, 1996). According to HCFA Statistics (1996), 76 million aged, disabled, and poor Americans -- well over one fourth of the U.S. population of 263 million -- were expected to receive health coverage through the Medicaid and Medicare programs in fiscal year 1996; among them, nearly 62 million beneficiaries were projected to received medical services. Of those 62 million, one out of five, or more than 11.7 million persons, would use inpatient hospital services covered by Medicare or Medicaid from 6,376 inpatient hospital facilities during 1996. HCFA paid $77.4 billion for Medicare inpatient hospital care and $24 billion for Medicaid general hospital care, a total of $101.4 billion, in fiscal year 1995. Hospital quality is of great interest. HCFA needs to assure itself that it is buying quality care for its 76 million beneficiaries. The Medicaid and Medicare programs have the responsibility to set benchmarks, and to

monitor and evaluate the provision of health care by providers and managed care organizations through which the care is delivered.

Health care cost and quality will continue to be the focus of health care reform, especially for government programs such as Medicaid and Medicare. With deficits and budget cuts, these government programs will likely see slower growth in their resources, even as they serve an increasing number of Medicare beneficiaries resulted from an aging population. The question becomes whether these government programs can still deliver quality care with limited resources and ensure that lower cost does not compromise quality of care. To do so, Medicaid and Medicare programs must establish systems to monitor and evaluate patient outcomes, and make outcome information available for the decision makers, and their beneficiaries at large, while controlling health care costs.

The need for outcome data also applies to managed care health plans. According to an InterStudy HMO industry report (1997), commercial health plans nationally served almost 67 million people, 26.7% of the U.S. national population. Among the 67 million people, almost 4.8 million were Medicare HMO enrollees, 12.6% of the Medicare eligible population; and 5.5 million were Medicaid enrollees, 13.5% of the Medicaid eligible population as of January, 1997. It is expected these numbers will double by the year 2000. The managed care industry plays an increasingly important role in delivering health care, not only to the patients of private payers, but also to those of the public payers.

HCFA encourages Medicare beneficiaries to join managed care plans and allows the states greater flexibility in their Medicaid programs by granting Medicaid waivers. Many states with waivers now can restructure their Medicaid programs and cover additional low-income, uninsured people through managed care. With the waiver, Massachusetts expanded eligibility to 135,000 non-elderly effective July, 1997.

In Massachusetts, there were approximately 2.7 million managed care enrollees, 44.6% of the state population as of January, 1997 (InterStudy, 1997). This represents 14.6% total HMO enrollment growth over the same period in 1996. Among the 2.7 million HMO enrollees, about 99,000 were Medicaid enrollees, 12.4% of the state Medicaid eligible population; and 165,000 were Medicare enrollees, 16.9% of the state Medicare eligible population. The net Medicaid and Medicare HMO enrollment growth was 26.3% and 47.9%, respectively, over the same period in 1996, which suggests a much faster HMO enrollment growth among Medicare and Medicare beneficiaries than the 14.6% total HMO enrollment growth in Massachusetts. These numbers are expected to increase rapidly in next few years due to recent Medicaid and Medicare legislative changes. For example, HCFA is currently in a process of implementing several key Medicare changes to help Medicare beneficiaries join managed care plans and motivate managed care organizations to enroll Medicare beneficiaries (Chung, 1997).

As for the Medicaid program in Massachusetts, the Massachusetts Division of Medical Assistance is currently in a process to solicit bids from managed care organizations (MCOs) to provide comprehensive health care coverage to over 400,000 Medicaid beneficiaries who are not currently enrolled in MCOs (Division of Medical Assistance, 1997). Because increasing numbers of the Medicaid and Medicare beneficiaries enroll in managed care programs, it becomes more important to monitor and evaluate the performance of the health plans. The task of achieving quality care is no longer held in the hands of any single provider, but in a full spectrum participants of interdependent and integrated heath care delivery systems including not only providers but also consumers, insurers, payers, patients, and families.

The particular medical condition used in this study to measure quality of care in terms of outcome is acute myocardial infarction (AMI), commonly known as a heart attack). It is a high-risk and high-volume condition that is of special concern with Medicaid and Medicare patients since they are often sicker and older. Acute myocardial infarction is an occlusion of a coronary artery resulting in death of heart muscle. According to a study by Iezzoni et al. (1988), myocardial infarction is one of the leading causes of death in the United States and acute myocardial infarction is among the commonest and most costly causes of morbidity among American adults. In 1986, 320,000 Medicare admissions were assigned to AMI diagnosis related groups (DRGs).[1]

The study of patients with acute myocardial infarction in Massachusetts is of great interest to the Medicare and Medicaid programs. The latter was noted in a study by Young and Cohen (1992) at the Massachusetts Department of Public Health (DPH). Concerned that low Medicaid payment rates might compromise the accessibility and quality of medical care for Medicaid beneficiaries in Massachusetts, Young and Cohen conducted a study of 4,033 emergency patients admitted with a principal diagnosis of acute myocardial infarction to Massachusetts hospitals in 1987. Adjusting for patients' clinical and demographic characteristics, the study found that Medicaid patients had longer hospital stays but were less likely to receive three selected coronary procedures. Furthermore, the study found the mortality for Medicaid patients was almost twice as high as for privately insured patients. This study will provide further information concerning patient characteristics, hospital and treatment variables, and patient outcomes for Medicaid patients in Massachusetts.

It is important to examine and investigate structure and process of care variables from the technical modeling point of view. Inclusion of both structure and process variables, while controlling for patient demographics and clinical risk factors, makes the

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[1] More generally, coronary disease causes about 1.5 million heart attacks and 500,000 deaths a year (U.S. Department of Health and Human Services, 1991). The number of people with such a medical condition is expected to increase. According to Weinstein (1987), the number of people with angina, myocardial infarction, or cardiac arrest is expected to increase from six million in 1980 to about nine million in 2010, an increase of 50%. Cardiovascular disease has been found to cost $135 billion annually (U.S. Department of Health and Human Services, 1991).

model more comprehensive. Exploring structure and process of care variables is also important to policy makers as these variables contain valuable information for decision making. Policy makers can improve quality of care by influencing these variables and medical practices through medical practice standards and regulations.

Finally, the study will include all payer patients with fresh AMI in Massachusetts. The results of the study, thus, reflect and apply to the general population in Massachusetts.

This study addresses the following three specific questions:

Q1. What are the hospital attributes and process of care variables that are associated with AMI patient mortality controlling for patient risk factors?

Q2. Controlling for patient risk factors and hospital attributes, are there significant differences by hospitals and/or health plans in patient mortality?

Q3. Controlling for patient risk factors and hospital attributes, do Medicare and Medicaid AMI patients have the same mortality as those of private-payer patients?

Problem Statement

The concerns for quality medical care have become a major public issue (Wenzel, 1992). Currently there is little information available in Massachusetts to answer these questions despite increasing public interest in outcome information. Yet Massachusetts, with a high concentration of academic health centers, has the highest per capita health care costs, averaging $4,123 per person per year (Medicine & Health, 1995). The outcome measurement systems needed to answer the questions about patient outcomes largely do not exist. In some places where outcome measurement systems do exist, the outcome information is subject to the limitations of the methodologies and data. However, the information is not easily accessible for the public.

One place where such outcome information does exist is the Health Care Financing Administration (HCFA). HCFA started releasing hospital mortality rates for Medicare patients in 1986. Since then there have been increasing debates and demands in defining outcome measures and methodologies for assessing outcomes. One criticism of HCFA mortality data concerns its limited adjustments for severity of patient illness. The inadequate adjustments make it difficult to determine whether the variation in hospital mortality rates is related to the quality of care, or factors such as patient case mix. In addition, HCFA information is limited to Medicare patients only, and therefore may not be generalizable to other patients.

During the past few years each of the major federal health reform proposals -- President Clinton's, the Cooper/Grandy managed competition bill, and the Senate Republican proposal -- call for health delivery systems to report on their performance

(Leatherman, et al., 1994). Health outcome is specified as one distinct area for performance reporting. Although this part of the proposals is yet to be incorporated into federal law, several major quality monitoring and reporting initiatives are under way as health plans and providers respond to health care purchasers and large employer groups. The Health Plan and Employer Data and Information Set, known as HEDIS, is one of these initiatives in Massachusetts. HEDIS has now been incorporated in the NCQA (National Committee for Quality Assurance) credentialing process for health plans. HCFA rewarded a $2.37 million contract to support HEDIS data collection nationally, and promotes the expansion of HEDIS performance indicators to include Medicaid and Medicare enrollees in managed care. Medicaid HEDIS became available for the first time in 1996 in Massachusetts.

However, HEDIS lacks outcome measures. According to a special report in Consumer Reports, the current generation of measures tells little about health outcomes- the best standard by which to judge quality (Consumer Reports, 1996). Readmission and Cesarean section rates included in HEDIS are two measures perhaps most relevant to outcome measures, although the Cesarean section rate has very little meaning to Medicare patients. In addition, these are only crude measures without any consideration of patient risk or severity of illness. Although unadjusted outcome measures may help to screen potential quality improvement areas for further study, they do not allow provider comparison due to lack of risk adjustment. For instance, a tertiary hospital cannot be compared to a non-tertiary hospital because patients are often considered sicker in a tertiary hospital. Risk adjustment to control for patient risk factors must be used in order to compare providers with a different patient case mix. Furthermore, these measures do not provide needed answers to the questions that matter most to hospitalized patients: Do the patients live and return home, or suffer from adverse outcomes after hospitalization? In addition, HEDIS is not designed for average consumers but for employers, purchasing experts and providers. It requires that users have an in-depth knowledge of health care. Therefore, efforts such as HEDIS cannot be expected to provide patients with needed outcome information, or help an average consumer to make an informed decision about their physicians, hospitals and health plans. Adequate outcome measurement systems must be developed.

Several proprietary computerized software packages are currently available commercially allowing for risk and severity adjustment of patient illness. MedisGroups and APACHE are two such systems developed and used in outcome measurement, which will be discussed in detail in the next section. However, these systems are not designed for average consumers either, but for institutions and health care professionals. They are not only technical, but also costly. The cost for the core system of APACHE ranges from $200,000 to $400,000, depending on implementation, size, and number of databases (Morrissey, 1996). Because of their cost and greater demand for resources, many institutions cannot afford to use them.

In summary, the accountability problem of the health care industry is in part due to the failure of the health care industry to provide outcome information to consumers. Realizing the problem, three big HMOs in the nation and the American Association of Retired Persons and Families, a powerful consumer advocate group with 33 million members, recently called publicly for full disclosure of quality indicators (Knox, 1997). The three HMOs include Kaiser, Health Insurance Plan of New York, and Group Health Cooperative of Puget Sound, which together insure 10 million Americans. Publicly disclosed and reliable outcome information, is essential for the health care industry to demonstrate its accountability and restore consumers' confidence in the U.S. health care delivery system.

Further, the importance of making outcome information available to the patients lies in the market approach to reform in health care, which is the driving force of the current debate on heath care reform. This market approach relies on the individuals' preferences/choices and seeks to allocate health care resources through consumers' choices of providers and payers (Rother, 1992). As a result of outcome information available, consumers benefit from high-quality and cost-effective health care.

Some proponents of federal health programs have argued against a competitive health care market (Ricardo-Campbell, 1982). According to their arguments, health care consumers cannot make sensible choices because of lack of expertise or time. In addition, consumers cannot foresee or adequately budget for health costs. Therefore, the market approach to health care cannot possibly work. However, health care consumers can make choices (Butler, 1989). In fact, callers to the 1-800 hot line recently established by the Board of Medicine in Massachusetts to provide consumers with physician malpractice information demonstrated that consumers can and want to make informed choices if they have the necessary information. After all, when it comes to choices of doctors and hospitals, who does not want to have the best available? But outcome information is the key that enables consumers to make informed choices of their providers and payers. Because the market approach to reform health care depends on consumers' choices/preferences, supporters of this approach can stimulate the health care market by encouraging consumers' choices of providers by providing consumers with needed information.

Although there is a great public demand for outcome information, current outcome measurement systems and initiatives are limited to serve only employers, purchasers, and providers. They provide little information that helps the patients make an informed decision about their providers and health plans. Furthermore, current outcome measurement systems and initiatives provide little explanation about provider outcome variation, which impedes effective policy and program interventions. Valid explanations about outcome variation are essential for policy making and for continuing quality improvement in the U.S. health care delivery system. Factors that may be responsible for the outcome variance should be identified and examined. There is an urgent need for

adequate outcome measurement systems that can answer the questions and provide explanations about outcome variation.

Overview of the Study

As pointed earlier, there exists literature and empirical work on quality assessment. Chapter 2 will begin with a review of the approaches to heath care quality assessment. The review will help in discovering relevant aspects associated with hospital outcome assessment. The outcome approach has now become the focus of quality assessment because it can answer those outcome questions discussed earlier that matter most to patients, providers, and purchasers. The literature review will proceed with the utility of mortality in patient outcome measurement, and will conclude with a discussion of current outcome measurement tools and previous empirical studies on AMI patient outcome measurement and related issues.

The conceptual framework of the present study formulated to investigate AMI patient outcomes is provided in Chapter III. This framework was developed based on the Medical Outcomes Study (MOS) model by Tarlov, et al. (1989) and others. The MOS was selected and adopted because this study is based on the assumption that attributes of hospital structure and processes of care, as well as patient demographics and clinical characteristics, are determinants of patient outcomes. An AMI outcome model was derived from the framework.

Chapter IV is devoted to the methods used in the study in estimation of the variables that influence patient outcomes. This chapter outlines the model specification and variable definitions, as well as analytical plans used in investigating factors associated with patient outcomes, invasive procedure use, and modeling of patient outcomes and invasive procedure use. Discussion of the data source is also included in the chapter.

Chapter V will start with descriptive statistics on the AMI patient population and comparisons among Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare as well as comparisons between patients who survived an AMI and patients who did not; between patients who had invasive procedure use and patients who did not. These descriptive statistics and significant findings guided the selection of variables and helped the development of patient outcome model and process model. The chapter will proceed with a discussion of specific model development and will be followed by parameter estimates of the models and interpretations of attributes that influence patient outcomes and process of care. Hospital mortality results are also presented. Chapter V will end with an estimate of indirect effects of being a Medicaid and a Medicare patient on mortality outcome due to differences in invasive procedure use.

The study ends with Chapter 6 where conclusions and recommendations are made concerning quality improvement based on the study results. Limitations of the study and areas for future researches are also discussed.

CHAPTER 2

LITERATURE REVIEW

This section will begin with a review of the approaches to heath care quality assessment. The review will help in discovering relevant aspects associated with hospital quality assessment. The outcome approach has now become the focus of quality assessment because it can answer those outcome questions discussed earlier that matter most to patients, providers, and purchasers. The literature review will proceed with a discussion of using mortality to measure patient outcomes, and will conclude with a discussion of current outcome measurement tools and previous empirical studies on AMI patient outcome measurement and related issues.

Hospital Quality Assessment Methods and Approaches

Quality of health care is defined by the National Academy of Sciences as, "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Donnabedian, 1988). Donnabedian, an expert in health care quality, developed a well-accepted approach to assess health care quality: structure, process, and outcome. Structure refers to the basic characteristics of health care providers. Structure measures include the physical facilities, the hospital personnel, and the licensing and credentialing of providers. Process refers to the actual delivery of the care. Process measures describe what doctors, nurses, and other health professionals actually do to the patients as they care for them. They include appropriate selection of treatment procedures and tests; use of prescription of drugs; and documentation of patient care. Outcome refers to the end result of clinical care. Donnabedian, defined outcomes as "those changes, either favorable or adverse, in the actual or potential health status of persons, groups or communities that can be attributed to prior or concurrent care" (Blumberg, 1986). Outcome describes what happens to patients after they receive care. Examples of outcome measures include recovery of patients, complications, and mortality. This three-pronged approach of Donnabedian forms a solid theoretical framework for evaluating and measuring quality care.

The traditional view of health care quality has focused primarily on the review of health care structures and processes (Splizer, 1991). Hospital quality assessment typically depends on case reviews. This is a method in which a doctor looks at medical records and makes a judgment as to whether the care rendered was good or bad. It is a judgmental call and a crude quality assessment method. But this method is still employed by the Provider Review Organization (PRO) to date, which has been assigned federal responsibility for quality of care review, primarily for Medicare patients. Based on medical record reviews, PRO determines which are better or worse providers.

Another traditional hospital quality assessment approach is based on the standards developed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). These standards are hospital structure and function focused. Hospitals must meet these standards in order to obtain JCAHO accreditation. Typically, JCAHO sends an on-site evaluation team into a hospital and evaluates the hospital against the standards. However, these standards address little about the direct care rendered to the patients or the well-being of patients in terms of patient outcomes.

Compared to the above two traditional methods of hospital quality evaluation, the outcome approach has not enjoyed much attention or popularity, until recently, when the purchasers of health care demanded that providers demonstrate the value of their purchases. Outcome measurement, thus, becomes a necessary and partial solution to the crisis of health care accountability. However, different from the traditional approaches to hospital quality assessment, this outcome measurement approach relies on data collected on the patients and providers. It uses statistical techniques to adjust for patients' risk/severity in order to make a judgment on the patient care and outcomes. The methodological advantage of such an approach is that it takes into account patients' differences and makes it possible to compare care among providers. Patients are unique individuals in reality, and they do differ in their severity of illness. As a result, each hospital may experience a different mix of patients. For instance, tertiary hospitals often see sicker patients; urban hospitals see more low-income patients. Therefore, these individual patient risks and severity of illness must be considered in the outcome measurement in order to make a fair comparison across hospital providers.

To respond to the increasing public demand for quantifiable quality care, JCAHO has recently required hospitals develop a performance measurement system which meets the needs of JCAHO. The system is expected to provide JCAHO with comparative data that can be incorporated into the survey and accreditation process and used to monitor hospitals' performance between on-site surveys (JCAHO, 1996). Each hospital measurement system is required to have attributes relating to process and outcome measures; technical capabilities to automate databases, disseminate performance measures internally, and transmit data to the Joint Commission; data integrity; risk adjustment; timely measure-related feedback; and relevance for accreditation. Although there is lack of standardization in the specific JCAHO hospital outcome measures and methodology, the development of such measures and methodology are still in their infancy, and no immediate hospital compliance is required by JCAHO, the outcome-focused approach has become one important component in JCAHO future accreditation process.

This outcome-focused approach is based on the so-called "algebra of effectiveness"; a concept that patient outcome is a complex function not only of the services provided, and other factors such as random events, but also of the patient's clinical attributes, including severity of illness (Iezzoni, 1989). This "algebra of effectiveness" is illustrated in the following figure (Iezzoni, 1989):

Clinical and other + patient attributes	Effectiveness + of care	Other factors including = random events	Patient Outcome

This "algebra" provides several reasons for explaining a given outcome. For a poor outcome in a given hospital, an explanation can be: sicker patient population; poor care; or bad luck (OSHPD, 1993). Risk adjustment is made based on the truism that severely ill patients are more likely to die than those less severely ill. Mark Blumberg, a noted expert in risk adjustment methodology, stated:

> "In order to compare outcomes of population in natural or nonrandomized "experiments", it is essential to adjust for attributes of patients prior to care which can influence outcome." (Blumberg, 1986).

In other words, risk adjustment takes into consideration complaints such as "my patients are sicker" or "my patients are older". It increases clinical reliability and validity of outcome measures. Using risk adjusted mortality outcome measures, therefore, helps to bring the assessment of health care outcomes closer to the reality where patient attributes and providers' patient casemix do vary. It also makes it possible to compare hospital providers and develop a benchmarking, e.g., an industry standard for quality of care based on patient outcomes.

The Utility of Mortality in Patient Outcome Measurement

During the past decade, mortality rates have been increasingly proposed as a measure of quality of hospital care (Annals of Internal Medicine, 1993). HCFA took the first step in 1986, releasing hospital mortality rates for Medicare patients to the public for the very first time. There are several reasons for using mortality as one measure of quality of medical care. Mortality is an objective end point and generally is more uniformly available than many other potential quality-of-care indicators, and moreover, for certain conditions, it measures a very relevant outcome (Annals of Internal Medicine, 1993). However, the concept of mortality as an outcome measure was not new.

Widely regarded as the father of epidemiology, Sir William Petty (1623-1687), a physician and Professor of Anatomy at Oxford, used mortality to question the outcome variation between London Hospitals and Paris Hospitals (White, 1992). In 1910, Codman, a prominent American surgeon on the staff of the Massachusetts General Hospital, expounded a simple proposal-the End Results Thesis (O'Leary, 1993). Codman encouraged fellow surgeons to look at their work through mortality and wanted to make the mortality information publicly available. Furthermore, he suggested that surgeons should get paid depending on patients' outcomes-e.g., mortality. Codman was very much concerned with mortality as a result of hospital care. He stated: "For the man who practices surgery, there are two kinds of mortality - chance and intentional. Chance mortality is the kind which occurs unexpectedly, and which no amount of foresight can prevent.... Intentional mortality is incurred by the chief surgeon when he attempts cases in

which the condition is acknowledge to be grave. It is speculative - like gambling against known chances in a game in which skill, judgment and luck all count." (Iezzoni, 1989, cited from Pearl, 1921).

Mortality is perhaps one of the most appropriate acute hospital outcome measure for AMI patients in Massachusetts. First of all, mortality as an outcome measure answers the question most important to the patients; second, AMI mortality is a public concern as AMI is one of the leading causes of adult death; third, mortality is uniformly collected and reported through the Freedom of Information Practice Act; finally, mortality data is an outcome measure readily available and less costly to be obtained as compared to other outcome measures such as functional status. Although functional status is widely used as an outcome measure (Tarlov, et al., 1989; Fowler, et al., 1994; Steward, et al., 1992; Ware, 1987), it typically depends on patients or clinicians for primary data collection, which can be costly and subjective.

Current Outcome Measurement Tools and their Limitations

As discussed earlier, hospital mortality measurement is not completely new. HCFA has developed a system called 'MMPS' (Medicare Mortality Predictor System) to calculate mortality rates within 30 days of admission for Medicare beneficiaries in four conditions. AMI is among these four conditions. This 'MMPS' system uses information taken from Medicare claims to report mortality rates for Medicare patients. HCFA first released its hospital mortality data in March 1986, which was a milestone for the development of outcome measurement, although the risk adjustment was very limited and inadequate at the time. The facility noted to have the most egregiously high mortality rate nationwide (87.6% of 1984 Medicare patients died compared to a governmental prediction of 22.5%) was a Las Vegas hospice facility caring for terminally ill patients (Iezzoni, et al., 1991). Apparently, it was inappropriate to compare a hospice to an acute hospital due to the significant differences of patient case mix and the nature of hospice services. Although the HCFA outcome information was only limited to Medicare patients, the public release of the HCFA hospital mortality data shook the medical community and the public. It furthered the development of outcome measures.

Following in the footsteps of HCFA, several state health agencies invested their own resources developing systems and models to report outcomes, such as mortality, using risk/severity adjustments. The Office of Statewide Health Planning and Development (OSHPD) under the Health and Welfare Agency in California, released hospital outcome data in 1994, known as Annual Report of the Hospital Outcomes Project. One of the outcome measures included in the report is in-hospital death within 30 days of admission for AMI patients. The mortality outcome measure was reported under two AMI mortality predictive models (Model A and B) using computerized hospital abstracts. The models incorporate two general types of risk factors: (1) demographic factors such as age and gender; and (2) clinical factors such as diabetes and cancer (OSHPD, 1993). Model A contains the demographic and clinical risk factors that reflect the patient's health at admission. Model B, a more

comprehensive model than Model A, contains all the risk factors in Model A as well as others that may reflect patients' quality of care. These AMI models are one step further than HCFA's MMPS.

Public concerns about quality of care fostered the development of computerized measurement systems allowing for risk/severity adjustment of patient illness. The APACHE II is such a system used for the outcome measurement. The APACHE (Acute Physiology and Chronic Health Evaluation) system aims to predict risk and severity for inpatients. APACHE II uses 12 commonly measured physiologic measurements. Each measurement is assigned a weight reflecting "how sick" a patient is. Because this system relies on physiologic measures, such as pulse and temperature, it requires extensive reviews of medical records instead of a computerized hospital discharge abstract. This means substantial costs are associated with using APACHE.

The Cleveland Health Quality Choice (CHQC), a well-known model for collaborative community-based outcomes assessment in the Cleveland metropolitan area, uses the APACHE III, an upgraded system of the APACHE II, to produce comparative hospital outcome data including in-hospital mortality. APACHE III uses patient-level data to develop predictors regarding the probability of in-hospital mortality and intensive care length of stay for each patient (Rosental, 1994). Compared to the APACHE II, the APACHE III is a more comprehensive system. The variables in the APACHE III predictive model include patient age, ICU admission diagnosis, patient comorbidity risk factors, admission source, and patient physiologic variables such as pulse, temperature, and arterial oxygenation. The data collection cost for the CHQC was said to be around seven million dollars. Such a costly study is clearly financially and politically challenging for the Medicaid and Medicare programs that operate within limited budget and resources.

MedisGroups is another measurement system developed by MediQual Systems, Inc.. This system aims to facilitate in-house quality assurance activities by identifying physicians whose experiences depart from the norm. MedisGroups produces severity scores, independent of patient diagnoses, based on risk for imminent "organ failure,' with the most severe cases actually experiencing "organ failure." (Iezzoni, et al., 1989). Like APACHE, MedisGroups requires medical records. The variables used in the MedisGroups to compute risk and severity scores include patient history, physical examination, lab results, pathology, radiology, and other procedures. Two states have so far implemented MedisGroups: Pennsylvania and Iowa. Pennsylvania publishes a quarterly hospital discharge report using MedisGroups. The report includes mortality and major surgery data.

In summary, the existing systems provide tools for risk/severity adjustment of patient illness in outcome measurement. They enhance the reliability and validity of outcome measurement, although each of them has its own share of limitations. However, these current outcome systems do not adequately address the attributes of structure of care or process of care, in particular those related to provider characteristics and processes of care, which may be associated with patient outcomes. These attributes can provide decision makers with

helpful and valuable information for making policy changes in provider practice. In essence, the above models seem to discount the interrelationships among structure, process and outcome emphasized by Donnabedian. Donnabedian (1988) stated:" good structure increases the likelihood of good process, and good process increases the likelihood of a good outcome". Donnabedian further stated that all assessments of quality are based, therefore, on hypotheses concerning the interrelationship among structure, process, and outcome; the assessments are valid only to the extent the hypotheses are verifiable. Therefore, it is important to explore the interrelationship among structure, process and outcome of care in quality and outcome measurement. Furthermore, the systems discussed previously provide little explanation for the outcome variation. Individual providers are left alone to interpret what went wrong with their organizations when there were poor outcomes and to identify areas of quality improvement that lead to better outcomes.

Previous Studies and Issues in Outcome Measurement

Patient Risk Factors

Previous empirical research suggests a number of variables ranging from AMI patients' demographics and clinical characteristics, to hospital structural characteristics and process of care that may account for patient outcomes. Many studies found that patients' gender and age were significant at the .05 level in association with patients' mortality (DeBusk, et. al., 1983; Franks, et al., 1996; Green, et al., 1990; Henning, et al., 1979; Leor, et al., 1993; Mark, et al., 1994; Naessens, et al., 1992; OSHPD, 1993). Racial difference was reported as statistically insignificant (OSHPD, 1993; Mark, et al., 1994). However, a study by Udvarhelyi, et al. (1992) found no significant gender difference in 30-day survival among AMI patients, but did conclude a reverse pattern of racial difference between black and white people in 30 day survival: black people had slightly better survival at 30 days than did white people. Udvarhelyi, et al. also reported that the use of coronary angiography, coronary artery bypass graft surgery, and percutaneous transluminal coronary angioplasty decreased with age and was less common among women and black race than among men and white race. Another study by Ritchie, et. al. (1993), which examined the in-hospital experience with coronary angioplasty and patient mortality using hospital discharge data, also concluded that female sex was not predictive among the AMI patient group.

Research also suggests an array of patients' clinical characteristics noted to have prognostic significance (DeBusk, et al., 1983; Gillum, et al., 1983; Gwilt, et al., 1985; Mark, et al., 1994; McClellan, et al., 1994; Pozen, et al., 1984; OSHPD, 1993; Zehender, et al., 1993). These clinical characteristics include: anterior wall site, cardiac arrest, cerebrovascular disease, congestive heart failure, chronic angina/ischemic heart disease, diabetes, diagnostic ECG, hypertension, high risk malignancy, inferior wall site, malnutrition, mitral valve disorders, myocardial infarct size, other or unspecified site, prior pacemaker, prior coronary bypass surgery, right ventricular infarction, renal disease, skin ulcer, subendocaredial location of an AMI, urinary tract infection, emergency and urgent admissions.

Institutional Characteristics

There appears to be some conflicting findings concerning institutional characteristics with hospital outcome. A number of studies suggest mortality outcomes associated with hospital characteristics such as tertiary status, hospital size, and financial performance (Cleverley and Harvey, 1992; Levitt, 1994; Shortell, et al., 1994; Tarlov, et al., 1989) while others concluded no associations between outcome and hospital characteristics (Staiger and Gaumer, 1996; Selker, et al., 1994). A research study by Cleverley and Harvey (1992) reported evidence of a relationship between hospital mortality and various measures of financial performance. Cleverley and Harvey used hospital-specific rates of mortality released by HCFA as a quality variable. They found that eight hospitals with low quality for four consecutive years had lower profits, lower investment in capital assets, and fewer staff hours per adjusted discharge.

A study by Stephen Shortell and colleagues (1994) on the performance of intensive care units (ICU) also provided evidence that hospital structural characteristics influence outcomes of care. The study examined the factors associated with risk-adjusted mortality, risk-adjusted average length of stay, and nurse turnover, and evaluated technical quality of care, and ability to meet family needs using data collected from 17,440 ICU patients. The study concluded that hospitals with significantly higher profits and involvement in teaching appear more likely to invest more in technology and have more technology available which, in turn, is associated with lower mortality.

Another study by Aiken, et al. (1994), comparing Medicare mortality between hospitals known for good nursing care and hospitals not known for good nursing care, also provided evidence that hospital structural characteristics are associated with patient outcomes. Controlling for patient age, sex, the presence of four comorbidities (cancer, cardiovascular disease, liver disease, and renal disease), the type and source of admission, the presence and risk of hospitalizations within the previous 6 months, the study found that hospitals with good nursing care had lower Medicare mortality. A mean +/-standard deviation comparison of about 17 hospital characteristic variables between hospitals with good nursing care and hospital without good nursing care led Aiken and her colleagues to conclude that the differences in hospital nursing organization were responsible for the mortality effect. These differences included not only a larger registered nurse ratio, but also greater status, autonomy, and control afforded nurses in hospitals with good nursing care, as well as their resulting impact on nurses' behaviors on behalf on patients.

A study by Samuel Levitt (1994) exploring the relationship between quality of care and investment in property, plant and equipment (PPE) in hospitals found that investment in PPE in Massachusetts hospitals is correlated with the Generic Quality Screen (GQS) confirmed screen failure rates. The GQS is a technique used by Peer Review Organizations (PRO) to detect and assure quality problems in the delivery of care to Medicare patients. The confirmed failures rates used by Levitt were screens of codes #1100 through #2600 involving two categories of failures: adequacy of discharge planning, and medicare stability of patient

within 24 hours of discharge. Levitt provided evidence of a relationship between quality and financial structure of the hospitals. To test the hypothesis that hospitals with the best quality invest more in PPE, Levitt used the data derived from audited financial statements and PRO's GQS reviews. Investment data in PPE was first standardized, summed by hospital over the six years, and divided by the hospital's average number of beds in that period. Confirmed failure rates by hospital were calculated by dividing the number of confirmed failures through PRO reviews by the total number of cases reviewed by PRO.

In contrast, a study by Staiger and Gaumer (1996) on the relationship between hospital financial pressure and patient outcomes in the Medicare program, found no evidence that mortality of Medicare patients was related to a hospital's financial condition, during the previous year, for more than 90% of Medicare patients with urgent-care admissions to hospitals with more than 150 beds. However, for smaller hospitals, the study did find that mortality within 45 days of admission was negatively related to a hospital's financial condition during the previous year (Staiger and Gaumer, 1996). In other words, the higher the mortality rate, the worse the financial condition of the hospital.

A study by Selker, et al. (1994) concluded that no hospital type was associated with significant differences between their actual and predicted mortality rates although urban teaching hospitals were found to have higher predicted mortality rates. To develop a time-insensitive predictive instrument (TIPI) for acute hospital mortality, Selker and his colleagues conducted a multi-center study. They used prospectively-collected data on 5,773 patients with chief complaints of chest pain or other symptoms suggesting acute cardiac ischemia, who came to six New England hospitals (including urban primary teaching, small city teaching affiliate, and rural non-teaching hospitals) over a 2-year period. However, this study only included a very small number of hospitals using data collected from 1979 to 1981, which may not be representative of the more than 80 acute hospitals located in Massachusetts and the recent technical advancement of invasive cardiac care.

Providers' Experience with AMI and the Use of Invasive Procedure

Previous empirical studies also provide evidence that hospitals' experience and processes of care are directly related to outcome of care (Hannan, et al., 1989; Luft, et al., 1979; Mark, et al., 1994; McClellan, et al., 1994; Udvarhelyi, et al., 1992). Luft and colleagues (1979) examined the relationship between a hospital's surgical volume, and its surgical mortality, using mortality rates for 12 surgical procedures performed in 1,498 hospitals. They found that the mortality of open-heart surgery, vascular surgery, transurethral resection of the prostate, and coronary surgery decreased with an increasing number of operations. The study concluded that certain operation procedures should be regionalized. A similar study by Hannan, et al. (1989) testing the combined relationship of hospital and physician volume, with in-hospital mortality rates, confirmed that five procedure groups had significant volume-mortality relationships. Another study by McClellan, et al, (1994) revealed that treatment at a high-volume hospital yields a survival benefit that begins at day one and persists throughout 4 years.

Udvarhelyi, et al. (1992) also found differences in procedure rates by gender and race on a national basis, and among the Medicare patients with relatively uniform insurance coverage. Concerning differences in process of care and outcome of care by age, gender, and race, Udvarhelyi and his colleagues evaluated the use of coronary angiography, CABG, and percutaneous transluminal coronary angioplasty (PTCA) in elderly patients with a new AMI, as well as the outcomes for these elderly patients in terms of their mortality. The study included 218,427 Medicare patients. The study reported that the use of coronary angiography was frequent, but decreased sharply with age; women and black people were less likely to undergo angiography than men or white people; and age influenced the decision to perform angiography more than the decision to perform a revascularization procedure once coronary anatomy was known. The study suggested that research is needed to reduce the mortality of elderly patients with AMI and to understand the significance of differences in procedure use on the basis of sociodemographic characteristics.

Gender differences were also noted in other studies (Steingart, et. al. 1991; Ayanian, et. al., 1991). Steingart and his colleagues conducted a study comparing the care received by men and women enrolled in a large post-infarction intervention trial. They found that men were twice as likely to undergo an invasive cardiac procedure as women, and physicians were less likely to pursue an aggressive approach in the management of coronary artery disease in women than in men. The study by Ayanian, et. al. (1991) used multiple logistic regression and hospital abstract data on 49,623 discharges in Massachusetts, and 33,159 discharges in Maryland, to estimate a patient's likelihood of a procedure use. The study concluded that women undergo fewer major diagnostic and therapeutic procedures than men, controlling for patient differences in demographics and clinical characteristics.

A study by Gornick, et. al. (1996) also confirmed race associated with patient mortality outcomes and use of services. The study calculated age adjusted mortality rates and age/sex adjusted rates of various diagnoses and procedures according to race and income among Medicare beneficiaries. Gornick and her colleagues reported that race and income have substantial effects on mortality and service use. Further, they concluded that Medicare coverage alone is not sufficient to promote effective service use. The study suggests patient demographics may be associated with patient outcomes and process of care, regardless the types of insurance coverage.

Another study by Goldberg, et. al. (1992) also concluded race was strongly associated with invasive procedure use, and physician supply was related to the CABG rates for white race. The study examined the differences in the rates of coronary artery bypass grafting (CABG) between white and black Medicare patients using the 1986 Health Care Financing Administration hospital claims records on all Medicare patients. The study found that the sex and age-adjusted CABG rate was 27.1 per 10,000 for white population, but only 7.6 for black population.

In contrast, a study by Mark, et. al. (1994) on the use of medical resources and quality of life after acute myocardial infarction in Canada and the United States, concluded that the

aggressive pattern of care in the United States may have been responsible for a better quality of life. The study found that the Canadian patients stayed in the hospital one day longer ($p=0.009$) than the U.S. patients, but underwent fewer invasive cardiac procedures. However, because of a lack of sufficient evidence, the study failed to reject the hypothesis that better outcomes of the U.S. patients were due to differences in the process of care.

Similarly, Berwick (1994), a well known expert in the field of quality care improvement, suggested that the procedure [test, surgery, hospital admission, laboratory test] cannot possibly benefit the patient from 15% to 50% of the time based on clinical science. Rating six procedures in a large database: coronary angiography, coronary artery bypass surgery, cholecystectomy, upper gastrointestinal tract endoscopy, colonoscopy, and carotid endarterectomy, based on unanimity of opinion that the procedure could not have helped a particular patient, expert panels found that 17% of the coronary angiograms, 17% of the upper GI endoscopies, and 32% of the carotid endarterestomies were inappropriate (Berwick, 1994). This seemingly suggests that giving more care or clinical procedures might not lead to better outcomes. In other words, increased procedure use alone does not guarantee good patient outcomes.

Another study by Winslow et. al. (1988) examined the appropriateness of performing coronary artery bypass surgery using a stratified random sample of patients who had bypass surgery in three hospitals in the years 1979, 1980, and 1982. The study found that 56% of the cases with coronary artery bypass surgery performed for appropriate reasons, 30% for equivocal reasons, and 14% for inappropriate reasons. The study concluded that there were significant differences in the appropriate use of coronary artery bypass surgery and eliminating the inappropriate procedure use might improve patient outcomes.

In summary, patient risk factors, hospital attributes, and invasive procedure use, appear to be the most important determinants of AMI patient outcomes. Previous studies found evidence that patients' demographics, clinical diagnoses and prognosis, provider structural characteristics, and process of care are related to patients' outcomes, although some findings in particular those of hospital characteristics were conflicting and disputable in some studies. This researcher expects that tertiary hospitals and hospitals with more investment in equipment and technology, and nurse resources, will enjoy better AMI outcomes than non-tertiary hospitals or hospitals with less investment in equipment and technology, and nurse resources in Massachusetts. Hospitals which perform a larger number of cardiac procedures with a higher volume of AMI admissions are also expected to have lower AMI mortality rates, than those hospitals which perform a smaller number of cardiac procedures with a lower volume of AMI patients. However, the literature seems to reveal strong disagreement about the effects of invasive cardiac procedures on AMI patients' mortality outcomes.

It is worth noting, a patient demographic variable (geographic location), which has to do with timely access to cardiac care, is seemingly omitted from the above AMI studies and existing outcome measurement systems. It is known that timely access to cardiac care is essential for the survival of AMI patients. A heart attack patient suffered from severe heart

damage a couple of years ago when he was turned away from Fallon Medical Center in Worcester. Luckily the patient survived because he managed to drive himself to the emergency room of another local hospital. His survival depended on getting access to cardiac care in time.

A study by McClellan, et al. (1994) found that rural patients as a group had significantly worse acute and long-term outcomes as a result of their greater likelihood of receiving treatments at lower-volume, noncatheterization hospitals. The study recommended that a redirection of resources, from marginal catheterizations and revascularizations, to improving access to some of these acute treatments could improve AMI mortality in the elderly and may reduce costs. Therefore, patients who reside outside the Boston metropolitan service area (MSA) where hospitals perform lower-volume invasive cardiac procedures, and availability of invasive cardiac treatment may be limited, may have poorer AMI outcomes in comparison to patients who reside in the Boston metropolitan service area (MSA), where there is a high concentration of academic tertiary hospitals in which invasive cardiac treatment is widely available and a large number of procedures are performed each year.

CHAPTER 3

CONCEPTUAL FRAMEWORK

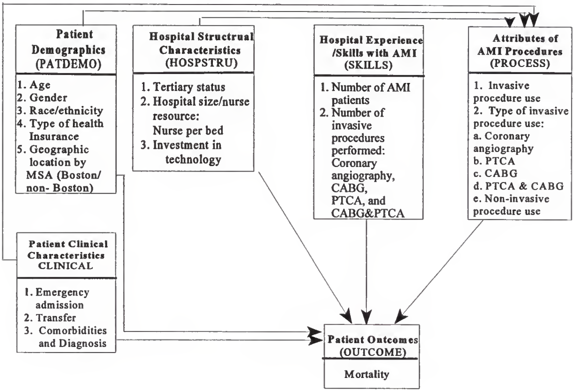
The preceding literature review has demonstrated that there are significant issues in outcome measurement, particularly the relationships between structure of care and outcome of care; and between process of care and outcome of care. The literature review has also demonstrated an array of variables associated with patient mortality outcomes and invasive procedure use, although the findings for some of the variables were inconclusive, and in some cases the results were disputable. However, the literature provides strong evidence that patient outcomes are associated with patient social and clinical risk factors, and further are related to attributes of the structure and the process of care. In light of the complexity of outcome measurement, this study addressed the central research question: what are the predictors for mortality of patients with acute myocardial infarction?

To address the above central research question pertinent to patient outcomes, the study developed an analytic framework to explore and identify patient characteristics, hospital characteristics, and process of care variables that may be associated with patient outcomes. The literature review in the previous section suggests an almost inexhaustible list of variables related to patient outcomes. It includes the following: patient demographics; patient clinical diagnoses and cormorbidity; provider structural characteristics; provider financial performance; provider experience with AMI, and the use of AMI invasive diagnostic and therapeutic procedures; (Blumberg, 1986; Hannan, et al., 1989; Mark, et al., 1994; McClellan, et al., 1994; Naessens, et al., 1992; OSHPD, 1993; Selker, et al., 1994; Steingart, et. al., 1991; Tarlov, et al., 1989; Udvarhelyi, et al., 1992; Winslow, et. al., 1988). Building on the conceptual framework of the Medical Outcomes Study (MOS) by Tarlov, et al. (1989) and others, the study's conceptual framework selects five types of variables that may be associated with patient outcomes: (1) patient demographic variables, for example, patient age, gender, race/ethnicity, or health insurance coverage; (2) patient clinical characteristic variables that arise from the medical condition, for example, diagnostic complexity of AMI admission and comorbidity; (3) hospital structural characteristic variables, for example, tertiary status, investment, and nurse per bed ratio; (4) hospital characteristic variables that can be linked to the experience and skills treating AMI patients, for example, the number of cardiac procedures performed or the number of AMI admissions; and (5) AMI invasive procedure use that can be linked to patient processes of care, such as the use of coronary angiography or CABG. The first three types of variables are also chosen by the conceptual framework as variables which may be indirectly impact patient outcomes through their influences on process of care. In other words, these variables may be associated with process of care, which may, in turn, influence patient outcomes. The study's conceptual framework is presented in Figure 1 on page 23.

The MOS was designed to help in understanding how specific components of the health care system affect the outcomes of care. The MOS framework is adopted because

Figure 1

Framework to Explore Preditors of Patient Outcomes



this study is based on the assumption that attributes of structure of care including patient and hospital characteristics; and process of care variables including patient invasive procedure use, are determinants of patient outcomes. These attributes and process of care are measured through a set of variables that will be discussed in detail later in this section. Therefore, the research objectives of the study are to identify predictors of patient outcomes; to support Medicare and Medicaid programs in assuring quality care to beneficiaries; and to generate policy recommendations concerning outcome measurement and quality improvement in hospital care.

The MOS lists a number of attributes of structure of care and process of care, including system characteristics; provider characteristics; and patient characteristics, that might account for some of the variation in patient outcomes. In the present study's conceptual framework, five types of variables were used as measures of structure of care and process of care defined in the MOS: (1) patient demographics; (2) patient clinical characteristics; (3) hospital characteristics; (4) hospital experience/skills with AMI; and (5) attributes of AMI invasive procedure use. The first four types reflect the structure of care and

the last reflects the process of care. These specific variables are derived from the literature review and can be obtained through available data.

Patient Demographics

In the study's conceptual framework AMI patient demographics include age, gender, race, type of health insurance coverage, and geographic location. For example, uninsured patients are more likely to experience poor outcomes than insured patients (Davis, K., 1997). Obviously individuals without health coverage lack access to health services. Providers are likely to allocate less resources to uninsured patients than insured patients because of resource constrains faced by the providers. As a result, uninsured AMI patients may receive fewer procedures and suffer from poorer outcomes than insured patients. This may also be the case for HMO patients, as managed care patients are typically required to have HMO authorizations for costly inpatient care and surgical procedures, which may pose an access barrier for managed care patients in some cases.

A recent phone survey of 1,000 consumers, conducted by the Patient Access to Specialty Care Coalition gave HMOs low marks for specialists and revealed that people trust their auto mechanics more than they trust their HMO (Pham, 1996). Another recent national survey on public attitudes toward managed care conducted by the Kaiser Family Foundation and Harvard School of Public Health, revealed that most American do not trust managed care health plan (Knox, 1997). People surveyed were worried that their health plans would be concerned about saving money than the best treatments for them. These survey results suggest negative attitudes and shaking public confidence toward managed care.

According to a survey of cardiovascular specialists by American College of Cardiology (ACC), the most frequently mentioned reason for not participating in managed care arrangements was "concern over the quality of care" (DeMaria, et al., 1994). More than half of the specialists surveyed were concerned that the gatekeeper approach of managed care might not be appropriate in the management of cardiac emergencies. Thus, HMO patients may experience poorer outcomes than those patients with health coverage through a traditional indemnity plan which puts patient care solely under the providers' discretion and allows patients an unrestricted choice of his/her physician. However, the emphasis by HMOs on the role of the primary care provider as gatekeeper and coordinator for all health care services is believed to contribute to the potential for managed care to control costs while maintaining quality (Safran, et al., 1994).

In addition, HMOs emphasize preventative care and utilization review, which improves patient health status and efficiency of resource allocation. There has been some empirical evidence that managed care can reduce costs without compromising quality of care (Manning, et al., 1984). Thus, HMO AMI patients may experience better outcomes as a result of appropriate care and efficiency in managed care or at least similar outcomes as non-HMO patients.

A study by Clement, et al. (1994), which examined the differences in access to care and medical outcomes for Medicare patients with an acute chest pain and joint pain who were enrolled in HMOs, compared with similar fee-for-service nonenrollees, confirmed no differences in outcomes in terms of complete elimination of symptoms, although HMO enrollees had reduced utilization of services. But the study also showed that HMO enrollees with continued joint pain reported less symptomatic improvement than nonenrollees. This present study analyzed and estimated the influence of the variables concerning types of insurance coverage on AMI patient outcomes.

The hypothesized relationships in the conceptual framework also suggest patient demographics associated with processes of care, and the indirect relationships between patient demographics and outcomes through the influences on process of care. Previous studies concluded differences in procedure rates by gender and race on a national basis, and among Medicare patients with relatively uniform insurance coverage (Ayanian, et. al., 1991; Goldberg, et. al., 1992; Gornick, et. al., 1996; Steingart, et. al., 1991; Udvarhelyi, et al., 1992). Women, black people, and older patients were found less likely to undergo invasive diagnosis or therapeutic treatments than men, white people or younger patients. A report by the Institute of Medicine (1992) on access to health care in America concluded that there is evidence of inequity in the receipt of ambulatory care, immunizations, dental visits, and some sophisticated procedures. The present study contributed to a further understanding of the significance of differences in procedure use on the basis of patient socio-demographics in association with patient outcomes.

Patient Clinical Characteristics

Patient clinical characteristics describe patient medical conditions that influence patient outcomes. Research suggests patient's clinical characteristics noted to have prognostic significance (DeBusk, et al., 1983; Gillum, et al., 1983; Gwilt, et al., 1985; Mark, et al., 1994; McClellan, et al. 1994; OSHPD, 1993; Zehender, et al., 1993). The study defined and estimated the influence of AMI patient clinical characteristics on outcomes based on statistical analysis as well as previous studies on AMI patients. ICD-9-CM principal and secondary AMI diagnoses were used to identify patient clinical characteristics. Dummy variables were created to indicate presence or absence of patient clinical characteristics and parameters of these patient's clinical characteristics were used to model patient outcomes. A detailed list of ICD-9-CM codes included in the analysis can be found in Appendix B. These codes were adopted from the Hospital Outcomes Project by the Office of Statewide Health Planning and Development (OSHPD) under the Health and Welfare Agency in California (OSHPD, 1993), and other previous studies. A team of medical and coding experts identified and recommended these codes for the OSHPD's Hospital Outcomes Project. All the codes were further verified against the manual of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) published by St. Anthony Publishing Inc. in 1996 prior to the analysis.

The hypothesized relationships in the conceptual framework also suggest that patient clinical characteristics are related to process of care. These clinical characteristics are not only associated with patient outcomes but also the processes of patient care. The correct clinical diagnosis leads to determinations of the treatment procedures to be used for patient care.

Hospital Structural Characteristics

Hospital structural characteristics refer to variables such as tertiary status; investment; and nurse resources. Some research suggests these hospital characteristics affect outcomes (Cleverley and Harvey, 1992; Levitt, 1994; Staiger and Gaumer, 1996; Shortell, et al., 1994; Staiger and Gaumer, 1996, Tarvol, et al., 1989). For example, hospitals that had higher profits and invested in technology with involvement in teaching were associated with lower mortality (Shortell, et al., 1994). However, others found no evidence of association between hospital financial conditions and mortality rates for mid-to-large hospitals (Staiger and Gaumer, 1996); or between hospital type and mortality rate (Selker, 1994). Thus, it is important to distinguish hospitals and account for hospital differences such as tertiary, and non-tertiary, so that the structural differences can be controlled and mortality results can be compared.

The conceptual framework also suggests that hospital structural characteristics are related to process of care. Hospitals differ in their capacity to perform invasive procedures or care for AMI patients since some hospitals invest resources in advanced cardiac diagnosis and treatment technology, and, therefore, provide invasive cardiac procedures; some do not. For example, hospital structural characteristics such as tertiary status, investment, and nursing resources, may be associated with invasive procedure use, which, in turn, may indirectly impact patient outcomes through their influences on process of care. A study by Blustein et. al. (1993) on high-technology cardiac procedures examined the impact of the in-hospital availability of three cardiac procedures on their use in AMI patients, using the New York statewide hospital discharge abstract data set. The study concluded that the availability of cardiac services in the hospital strongly influenced the likelihood of their use among their AMI patients. Therefore, hospital structural characteristics may determine whether their patients have invasive procedure use during their hospitalization.

Hospital Experience/Skills with AMI

Practice makes perfect as the old saying goes. A hospital provider with considerably more experience operating on AMI patients may produce better patient outcomes than others. Research suggests that hospital mortality rates are related to hospitals' volume of surgical procedures and AMI patient volume (Hannan, et al., 1989; Luft, et al., 1979; McClellan, et al., 1994). This may be also true in the case of AMI patient outcomes in Massachusetts. In the conceptual framework, the variables used to measure experience/skills include the volume of AMI patients, and number of major AMI surgical procedures performed. The study estimated the influence of these variables on patient outcomes.

Process of Care Variables

The MOS lists process of care as an important component in explaining and determining patient outcomes. Research suggests that invasive cardiac procedure use influences patient outcomes (Ghali, et. al., 1997; Mark, et al., 1994; McClellan, et. al., 1994; Stone, et al., 1996, Udvarhelyi, et al., 1992). For example, primary percutaneous transluminal coronary angioplasty (PTCA) in patients with anterior wall AMI results in significantly improved survival (Stone, et al., 1996). The study thus analyzed and estimated processes of care variables on patient outcomes.

In summary, the conceptual framework developed based on the MOS model incorporates attributes from both structure of care and process of care in the outcome evaluation. The framework suggests five domains of variables associated with patient outcomes. These five domains include patient demographics, clinical characteristics, hospital structural characteristics, experience/skills, and process of care. In addition, the conceptual framework suggests patient demographics, clinical characteristics, and hospital structural characteristics, are associated with process of care, which, in turn, may indirectly impact patient outcomes through their influences on patient process of care.

CHAPTER 4

METHODS

Model

Statistical analysis was used to answer the three study questions: (1) what are the hospital attributes and process of care variables that are associated with AMI patient mortality controlling for patient risk factors? (2) controlling for patient characteristics, hospital characteristics, and process of care, are there differences by hospitals in patient mortality outcomes? and (3) controlling for patient risk factors, hospital attributes, and process of care, do Medicare and Medicaid AMI patients have the same mortality as those of private-payer patients? The literature review in Chapter II and the conceptual framework described in Chapter III support the application of the patient model expressed in two equations of the following general form:

(1) OUTCOME $= f$(PATDEMO; CLINICAL;HOSPSTRU; SKILLS; PROCESS)

or

$$\text{OUTCOME}^* = B_0 + B_1\text{PATDEMO} + B_2\text{CLINICAL} + B_3\text{HOSPSTRU} + B_4\text{SKILLS} + B_5\text{PROCESS} + e$$

Where OUTCOME* is a continuous measure of patient outcome; PATDEMO represents patient demographic characteristics measured by variables including patient age, race, type of insurance coverage, and residential geographic location; CLINICAL represents patient clinical characteristics measured by variables including emergency admission, transfer, and clinical diagnosis; HOSPSTRU represents hospital structural characteristics measured by variables including hospital type, investment, and nursing resources; SKILLS represents hospital experience with AMI, measured by the annual volume of AMI patients a hospital treats; and PROCESS represents invasive procedure use. The betas are coefficients to be estimated, and e is an unobserved disturbance, independently and identically distributed across patients, and independent of the variables in the model.

OUTCOME* is not observed. Rather, a censored version of it, OUTCOME, is observed, where OUTCOME=1 (death) if OUTCOME*>0, and otherwise OUTCOME=0 (survival). The model was estimated using the logit MLE estimator, assuming that e is distributed according to a hyperbolic-secant-square distribution. The cumulative distribution of such a distribution is the logistic function.

(2) PROCESS $= f$(PATDEMO; CLINICAL; HOSPSTRU)

or

$$\text{PROCESS}^* = B_0 + B_1\text{PATDEMO} + B_2\text{CLINICAL} + B_3\text{HOSPSTRU} + e$$

Where PROCESS* is a continuous measure of patient invasive procedure use; PATDEMO represents patient demographic characteristics measured by variables including patient age, race, type of insurance coverage, and residential location; CLINICAL represents patient clinical characteristics measured by variables including emergency admission, and clinical diagnosis; HOSPSTRU represents hospital structurual characteristics measured by variables including hospital type, investment, and nursing resources. The betas are coefficients to be estimated, and *e* is an unobserved disturbance, independently and identically distributed across patients, and independent of the variables in the model.

PROCESS* is not observed. Rather, a censored version of it, PROCESS, is observed, where PROCESS=1 (invasive procedure use) if PROCESS*>0, and otherwise PROCESS=0 (no invasive procedure use). The model was estimated using the logit MLE estimator, assuming that *e* is distributed according to a hyperbolic-secant-square distribution. The cumulative distribution of such a distribution is the logistic function.

Figure 1 on page 23 provides a diagram for above equations. Specific definitions of the variables are discussed later in this chapter. Equation 1 suggests that AMI patient outcome is a function of patient demographics, clinical characteristics, hospital structure, and skill in treating AMI patients; Equation 2 suggests that process of care is a function of patient demographics, clinical characteristics, and hospital structure characteristics. Modeling Equation 2, it was possible to study those factors which might not only influence patient mortality outcomes directly, but also indirectly through the process of care as suggested in the diagram in Figure 1 on page 23. For instance, patient age might be associated with invasive procedure use, which, in turn, might indirectly impact patient outcomes through its influence on invasive procedure use.

Data Source and Patient Population

The data for the present study are primarily from two sources. The source of AMI patient data for the study is the Massachusetts Division of Health Policy and Financing (formerly the Massachusetts Rate Setting Commission) Hospital Case Mix and Charge Data, also called the Freedom of Information Practice Act (FIPA), created by the Division under the Commonwealth of Massachusetts 114.1CMR 17.00. The data are patient specific abstracted hospital discharge data. Hospitals are required to routinely submit such data to the Division which reviews and ensures the accuracy of the data through data screening and editing using a specially-designed data processing program. The data include patient age, sex, race, insurance status, admission source, ICD-9-CM principal diagnosis, secondary diagnosis, principal procedure, significant procedures, mortality results, charges, and the hospital identification number given by the Massachusetts Department of Public Health (DPH). The FIPA is also the data source for the hospital volume of AMI patients.

The source of hospital structural characteristic data is from the Hospital Statement for Reimbursement - RSC-403 for fiscal year 1995 collected by the Division. The RSC-403 was mandatory and all acute hospitals were required to submit their audited financial statements

through an electronic method. The Division also routinely audited the RSC-403 prior to Massachusetts hospital deregulation in 1996. The RSC- 403 data includes hospital structure and detailed financial information such as: hospital membership in the teaching council; the number of operating beds; profit and loss; return on assets; the number of full-time employees; the number of physicians and nurses; and investment activities.

The present study included all the patients with AMI diagnosis and length of stay 30 days or less who were hospitalized in Massachusetts during the state fiscal year 1995. Hospitalizations with discharge status as transfers to another acute hospital were excluded, which totaled 3,843 patients and was approximately 19% of the patient population. There were two reasons for the exclusion. One reason was that it is difficult to account for patient outcome of one episode of hospital care in more than one hospital. The other reason was the fact that not all the Massachusetts hospitals provided critical cardiac care services or performed invasive cardiac procedures. As a result, transfers were made for patients to obtain such services or procedures in another hospital where the services or procedures were available. Therefore, only patient data at the second, receiving, hospitals where patients were transferred after admission to initial hospitals were included in the study analysis.

In addition, 151 patients with race as other (approximately 0.8% of the study population) and 613 patients with race as unknown (approximately 3.1% of the study population) were excluded from the study. The exclusion was also applied to 253 patients with length of stay of over 30 days, 23 patients with invalid residential zip codes such as '00000' and '99999', three patients under the age of 18, one patient with unknown gender, one patient with unknown admission type, one patient with unknown admission source, and two patients with unidentifiable reimbursement type. Six hospitals with a total of 896 patients, and a hospital with an unknown hospital id, were excluded from the analysis due to either unavailability of the 403 data or incomplete 403 data elements. Four small hospitals with 30 or less AMI patients were also excluded from the analysis due to too few cases. Of the 19,896 admissions initially identified with AMI diagnosis, 14,041 (approximately 71% of the study population) were included in the analysis.

Variables

The review of the literature and research discussed in Chapter II led to the identification of variables that are likely associated with patient outcomes. The operationalization of variables in this study is described below. Variables of interest were coded as binary variables or multiple dichotomous variables when more than two categories exist, such as race, type of insurance coverage, and type of invasive procedure use. Coding and variable details can be found in Appendix A.

As suggested in the conceptual framework of figure 1 in page 23, there are a total of five types of variables. These five types of variables are: patient demographics, clinical characteristics, hospital structural characteristics, skills and process related variables. Patient demographics include age, gender, race, type of insurance coverage, and patient residential

area. Age in years and age squared were used in the models. A binary variable of gender, and multiple dichotomous variables of race and types of insurance coverage were coded for each patient. The sum of all Native Americans, Asian and Pacific Islanders, African Americans, those of Hispanic origin, and Euro Americans was 100 percent of the study population. All races were used in the models, with Euro-Americans as base group. The coding of insurance coverage was based on primary payers which consisted of Medicaid program, Medicare program, Medicare managed care program, other government programs, free care, self-pay, indemnity plans, and managed care organizations. All payers were used in the analyses. Subsequent analyses were performed separately to categorize type of insurance coverage for modeling. Each patient was also coded with a binary variable of residential location indicating whether the patient lived in the metropolitan service area (MSA) of Boston, or outside the area based on patient zip code information and the MSA definition by the U.S. Census Bureau. The MSA zip code information was provided by DRI/McGraw Hill, a well-known information service company specialized in economic information.

Clinical characteristics refer to emergency admission, location of AMI, and other clinical conditions, including: anterior, anterolateral, inferolateral, or other lateral infarction; complete atrioventricular block; congestive heart failure; cardiomyopathy; chronic liver disease; chronic renal failure; diabetes, complicated; diabetes, uncomplicated; hypertension; hypotension; inferior infarction, posterior, inferoposterior; late effects of cerebrovascular disease; hemiplegia; other major cerebrovascular disease; mitral disorder; rheumatic valve disorders; aortic valve disorders; heart valve replacement; primary neoplasm of GI, respiratory, melanoma; pulmonary edema; adult respiratory distress syndrome; epilepsy, convulsions; shock; infarction other or unspecified; chronic skin ulcer; and subendocardial infarction. Each patient was coded with a binary variable of these clinical characteristics. The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes were used to identify patient clinical characteristics and process of care. A detailed list of ICD-9-CM diagnosis codes used for these clinical characteristics can be found in Appendix B.

Hospital structural and experience/skill variables included in the models were: hospital AMI volume; investment in gross plant, property and equipment (PPE); nurse per bed, and tertiary status. The choice of these variables was made due to multicollinearity problems among the hospital characteristic variables, which are further discussed with the results presented in Chapter V. All the hospital characteristic information, except tertiary status, was based on the 403-RSC for fiscal year 1995 submitted to the Division of Health Policy and Finance by the hospitals. Although the RSC-403 has information on hospital membership with the Teaching Council discussed earlier, a further review of the 22 hospitals reported memberships with the Teaching Council suggests that these 22 hospitals could not possibly all be tertiary hospitals based on their size, referrals, and tertiary contracts with managed care. There appears a lack of documentation and consensus on which hospitals are tertiary hospitals in Massachusetts. The researcher asked a dozen professionals ranging from M.D/Ph.Ds. to health care policy specialists, and found various answers, or no answers.

Tertiary status was then determined based on AMI patient volume, referrals, and teaching status, which resulted in a total of ten hospitals identified as tertiary.

The process of care variables included both invasive procedure use and type of invasive procedure use among AMI patients. Each patient was coded with a binary variable indicating whether the patient had invasive procedure use or not during his/her hospitalization. Invasive procedures refer to coronary angiography, percutaneous translumina coronary angioplasty (PTCA), or coronary artery bypass graft surgery. ICD-9-CM procedure codes were used to identify invasive procedures. A detailed list of ICD-9-CM procedure codes used in this study can be found in Appendix B. The binary variable of invasive procedure use was entered in the outcome models (see Appendixes C, D, and E).

Multiple dichotomous variables of invasive procedures were also coded for each patient to categorize a specific type of invasive procedure use. The sum of all patients with coronary angiography, PTCA, coronary artery bypass graft surgery, a combination of both PTCA and bypass surgery, and non-invasive procedures, is 100 percent of the study patient population. All types of invasive procedure use were used in the final outcome model (2) of Appendix F and G with patients who had no invasive procedure use as base group.

Data Analysis

First, descriptive statistics were used to summarize and describe all major variables by Medicaid patients, Medicare patients, and patients other than Medicare or Medicare. These variables were to be tested in the logistic regression models discussed earlier in this Chapter. The literature review in Chapter II led to the initial identification of those variables likely to impact AMI patient outcomes and procedure use. The variables included patient demographics, clinical characteristics, hospital structural characteristics, experience with AMI, and process of care variables. A chi-square was used for categorical variables, and an analysis of variance was used for continuous variables, to compare Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare.

The second stage of analysis involved an exploration of the relationships between patient outcomes and the variables in each domain of the framework; and between invasive procedure use and the variables associated with procedure use. A chi-square and a t-test were performed to compare differences between patients who survived and who died; and between patients who received an invasive procedure and those who did not. A chi-square was used for categorical variables and a t-test was for continuous variables. In addition, a Pearson correlation was employed to further explore the relationships among the variables and to test for possible multicollinearity. Factor analysis was then attempted to correct the multicollinearity found among hospital characteristic variables. These analyses were helpful for data reduction decisions to be made concerning building the models and selecting independent variables which predicted and explained patient outcomes.

Finally, multiple logistic regression was applied to the two models discussed earlier in this chapter in order to investigate the more complex interrelationship between the structure of care and the process of care variables that might be responsible for some of the outcome variance. The use of logistic model has been considered by many researchers (Agresti, 1984; Hosmer and Lemeshow, 1989, Hannan, et. al, 1997). It employs the method of maximum likelihood to estimate the parameters of exploratory variables. The present study has used multiple logistic regression in the analysis because the dependent variables of the study were dichotomous. Logistic regression was applied to model between a dichotomous dependent variable (death=1; survival=0) and the set of independent variables which likely explained AMI patient mortality outcomes; between a dichotomous dependent variable (invasive procedure use=1; non-invasive procedure use=0) and the set of independent variables that might explain invasive procedure use. The later is important to investigate and understand factors associated with invasive procedure use, which may indirectly impact patient outcomes through their influences on invasive procedure use.

For the purpose of demonstrating the model, the following specific hypotheses about patient outcome predictors and procedure use were tested. Because of the objectives of the present study, the most important hypotheses about patient outcomes were those concerning hospital structure characteristics, experience with AMI, and the procedures, as well as the form of insurance coverage patients participate in. These hypotheses were:

H_1: Holding all other factors constant, hospital attributes, particularly those related to tertiary status; investment; and nursing resources, are significantly associated with patient mortality outcomes and invasive procedure use.

H_2: Holding all other factors constant, patient health insurance coverage is significantly associated with patient outcomes and invasive procedure use. Significant differences in patient outcomes and procedure use are expected between uninsured and insured patients; between managed care and non-managed care patients; and among Medicaid, Medicare, and privately insured patients.

H_3: Holding all other factors constant, hospital experience with AMI is significantly associated with patient mortality outcomes.

H_4: Holding all other factors constant, invasive procedure use by patients are significantly associated with patient outcomes.

In the application of multiple logistic regression, the present study used SAS 6.12. The SAS LOGISTIC procedure was employed in the patient outcome model and the process model discussed earlier in this chapter to analyze and model the dichotomous variable of mortality outcome, and the set of independent variables in the framework that might

influence patient outcomes; and the dichotomous variable of procedure use and the set of variables that might explain invasive procedure use.

A number of models were generated before final models could be determined based on a goodness-of-fit comparison of the models. Parameter estimates and odds ratios from final outcome and process of models can be found in Appendices D and I.

CHAPTER 5

RESULTS

This chapter presents the results of data analyses. First, descriptive statistics were generated as an initial stage of data analysis and model development. These variables include patient demographics, clinical characteristics, hospital structural characteristics, experience/skills, and process of care. Differences among Medicaid, Medicare and other patients are presented. Second, differences between AMI patients who survived and those who did not, and differences between AMI patients who had invasive procedure use and those who did not, are compared and displayed. The significant findings of the differences guided the selection of independent variables and the development of the models. Third, data reduction is employed, which includes techniques such as a Pearson correlation and factor analysis. Fourth, patient outcome and process model development is discussed. Fifth, the results of multiple logistic regression models are shown, including parameter estimates of each independent variable in the models. Finally, the findings and interpretations of the model results are discussed including hospital outcome results and indirect effects of invasive procedures.

Descriptive Data Analysis and Statistical Tests

Data analysis began with descriptive statistics to summarize and describe all major variables that were to be tested in the logistic regression models discussed later in this Chapter. Table 1 summaries AMI patient demographics by total patient population, Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare. A chi-square test was employed to compare differences among these groups for all demographic variables except age. Because age is a continuous variable, analysis of variance was used instead. All demographic variables except the variable of residential area were found to be statistically significant, which suggests significant demographic differences among Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare. The data in Table 1 show that Medicaid patients and patients other than Medicaid or Medicare, not surprisingly, tended to be in younger age groups than Medicare patients, where a majority of patients were in age groups of 65 and above. The mean age for Medicare patients is 76 years old, compared to 56 years old for Medicaid patients and patients of other than Medicaid or Medicare. There appeared to be more males in the study population, with more Medicaid male than female patients, and particularly noticeable more males among patients other than Medicaid or Medicare. For patients other than Medicare or Medicare, the number of male patients was almost three times the number of female patients. However, there were less male than female patients among Medicare patients. The data also show that most of the patients were white. The number of non-white patients was extremely small and seemed particularly unrepresentative of African Americans and Latinos. This presents a possible mis-coding problem in the race variable which will be further discussed later in this chapter. In addition, Table 1 shows most of the patients lived in the Boston metropolitan service area

Table 1

Demographics of AMI patients by type of insurance coverage (N=14,041)

Demographics	All patients	Medicaid patients		Medicare patients		Patients other		Chi-square /F value
		Type of insurance coverage						
		Number and percentage of patients						
Total	14,041	350	(2.49)	9,204	(65.55)	4,487	(31.96)	
Age groups								
18-40 years	327	40	(11.43)	19	(0.21)	268	(5.97)	
41-54 years	1,940	100	(28.57)	150	(1.63)	1,690	(37.66)	
55-64 years	2,355	161	(46.00)	292	(3.71)	1,902	(42.39)	
65-74 years	3,827	27	(7.71)	3,371	(36.63)	429	(9.56)	
75-84 years	3,863	15	(4.29)	3,692	(40.11)	156	(3.48)	
85 years or over	1,729	7	(2.00)	1,680	(18.25)	42	(0.94)	9567.04**
Gender								
Female	6,110	165	(47.14)	4,723	(51.31)	1,222	(27.23)	
Male	7,931	185	(52.86)	4,481	(48.69)	3,265	(72.77)	713.55**
Race								
American Indian	38	2	(0.57)	21	(0.23)	15	(0.33)	
Asian	44	7	(2.00)	15	(0.16)	22	(0.49)	
Black	316	23	(6.57)	174	(1.89)	119	(2.65)	
Hispanic	223	48	(13.71)	100	(1.09)	75	(1.67)	
White	13,420	270	(77.14)	4,256	(94.85)	8,894	(96.63)	435.50**
Residential area								
Non-Boston	2,946	61	(17.43)	1,954	(21.23)	931	(20.75)	
Boston MSA	11,095	289	(82.57)	7,250	(78.77)	3,556	(79.25)	3.15
		Mean value						
Age	69.35	55.85		76.41		55.91		7595.66**

Note: Values in bracket represent percentages of patients. Non-Boston stands for Non-Boston Metropolitan Service Area (MSA). ** p < 0.01.

Table 2

Clinical characteristics of AMI patients by type of insurance coverage (N=14,041)

Clinical characteristics	All patients	Type of insurance coverage: Medicaid patients		Medicare patients		Patients other		Chi-square value
	Number and percentage of patients							
ER admission	8,848	239	(68.29)	6,206	(67.43)	2,403	(53.55)	253.36**
Transfer	3,267	58	(16.57)	1,695	(18.42)	1,514	(33.74)	405.86**
AMI location+								
Anterior	3,757	92	(26.29)	2,311	(25.11)	1,354	(30.18)	39.57**
Inferior	3,494	94	(26.86)	1,899	(20.63)	1,501	(33.45)	265.97**
Site other	1,110	23	(6.57)	914	(9.93)	173	(3.86)	153.78**
Subendocardial	5,957	147	(42.00)	4,258	(46.26)	1,542	(34.37)	174.87**
Other clinical characteristics+								
Complete atrioventricular block	324	7	(0.05)	241	(2.62)	76	(1.69)	11.59**
Congestive heart failure	5,474	122	(34.86)	4,448	(48.33)	904	(20.15)	1009.58**
Chronic liver disease	89	7	(2.00)	70	(0.76)	12	(0.27)	22.28**
Chronic renal failure	768	28	(8.00)	648	(7.04)	92	(2.05)	149.71**
Diabetes, complicated	704	38	(10.86)	482	(5.24)	184	(4.10)	33.91**
Diabetes, uncomplicated	1,902	49	(14.00)	1,322	(14.36)	531	(11.83)	16.54**
Hypertension	5,166	121	(34.57)	3,408	(37.03)	1,637	(36.48)	1.145
Hypotension	1,138	34	(9.71)	778	(8.45)	326	(7.27)	6.96*
Late effects of cerebrovascular disease	13,452	331	(94.57)	8,997	(97.75)	4,124	(91.91)	257.44**
Mitral disorder, rheumatic valve disorders, aortic valve disorders, heart valve replacement	952	20	(5.71)	785	(8.53)	147	(3.28)	132.33**
Primary neoplasm of GI, respiratory, melanoma	120	2	(0.57)	103	(1.12)	15	(0.33)	22.27**

Pulmonary edema, adult respiratory distress syndrome					
	603	23 (6.57)	471 (5.12)	109 (2.43)	57.56**
Epilepsy, convulsions					
	301	15 (4.29)	214 (2.33)	72 (1.60)	15.31**
Other major cerebrovascular disease					
	4,822	115 (32.86)	3,648 (39.63)	1,059 (23.60)	344.25**
Shock					
	43	1 (0.29)	34 (0.37)	8 (0.18)	3.61
Chronic skin ulcer					
	137	3 (0.02)	119 (1.29)	15 (0.33)	28.74**
Anterior infarction and late effects of cerebrovascular disease					
	572	11 (3.14)	228 (2.48)	333 (7.42)	189.49**
Prior CABG					
	37	1 (0.29)	26 (0.28)	10 (0.22)	0.42

Note: Values in bracket represent percentages of patients. + indicates a patient can have multiple clinical characteristics present. ** $p < 0.01$, * $p < .05$.

(MSA) and there seemed to be no significant differences among Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare in terms of whether the patients lived within the Boston MSA or not.

Table 2 provides summary statistics on patient clinical characteristics for Medicaid, Medicare, and patients other than Medicaid and Medicare. A chi-square test was also employed to test differences among the groups on these characteristics. All patient clinical characteristic variables were found to be statistically significant except hypertension, shock, and prior CABG, which suggests significant differences in patient clinical characteristics among Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare were present. The results in Table 2 show that more Medicaid and Medicare patients were admitted on an emergency basis, but less were transferred patients than patients other than Medicaid or Medicare. The percentage of patients with emergency admissions seemed to be highest, and the percentage of transfer patients, lowest, for Medicaid patients. More Medicaid and Medicare patients appeared to have clinical characteristics present than non-Medicaid or Medicare patients, for example, 35% of Medicaid and almost 50% of Medicare AMI patients had congestive heart failure in comparison with 20% of patients other than Medicaid or Medicare; 8% Medicaid and 7% Medicare patients had chronic renal failure in comparison with 2% non-Medicaid or Medicare patients. These indicate that Medicaid and Medicare patients might have more complex medical conditions and poorer health status.

Table 3 presents summary statistics on hospital characteristics by Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare. A chi-square test was used for categorical variables of hospital characteristics, while analysis of variance was applied to continuous variables such as hospital volume of AMI patients, and investment. All the

Table 3

Hospital characteristics by type of insurance coverage (N=69)

Characteristics	Type of insurance coverage Medicaid patients	Medicare patients	Patients other	Chi-square / F value
		Mean value		
Skills				
No. of invasive procedures/hospital	2,208.45	1,887.45	2,685.92	183.56**
Volume of hospital AMI patients/hospital	546.40	516.59	619.58	153.98**
Structural characteristics				
Investment in PPE (in billions)	0.22	0.19	0.25	95.92**
Hospital size/resources				
No. of operating beds	375.87	347.46	396.98	77.79**
Total no. of FTEs	2268.98	2001.59	2502.08	120.86**
Nurse per bed	1.29	1.25	1.37	180.98**
No. of registered nurses	518.37	463.45	569.17	115.83**
Tertiary status	Number and percentage of patients			
	136 (38.86)	2,841(30.87)	2,134 (47.56)	364.00**

Note: Values in bracket represent percentages of patients. PPE stands for gross plant, property and equipment and FTE for full time equivalents. ** $p < 0.01$.

variables concerning hospital characteristics were found to be statistically significant. These findings suggest significant hospital skill and structural differences among the hospitals in which Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare, received their hospital care. The data in Table 3 show that hospitals in which Medicare patients were hospitalized tended to have, on average, less experience in terms of the total number of invasive procedures and the volume of AMI patients in comparison with those hospitals in which non-Medicare patients were hospitalized. These hospitals also seemed to have less investment in PPE, and resources in terms of the number of registered nurses, total full time equivalents, and a lower ratio of nurse per bed. It is interesting to note that the hospitals which cared for patients other than Medicaid or Medicaid had the highest average values in each of the hospital characteristic variables. The data also suggest that a greater

Table 4

Process of care variables by type of insurance coverage (N=14,041)

Process of care	All patients	Medicaid patients	Medicare patients	Patients other	Chi-square / F value
		Type of insurance coverage			
	Number and percentage of patients				
Types of invasive procedure use+					
Coronary angiography	1,855	56 (16.00)	969 (10.53)	836 (18.50)	
Percutaneous translumina coronary angioplasty (PTCA)	2,220	50 (14.29)	945 (10.27)	1,225 (27.30)	
Coronary artery bypass graft surgery (CABG)	1,120	25 (7.14)	686 (7.45)	409 (9.12)	
Percutaneous translumina coronary angioplasty and coronary artery bypass graft surgery	95	1 (0.29)	37 (0.40)	57 (1.27)	
Non-invasive procedure use	8,751	218 (62.29)	6,567 (71.35)	1,966 (43.82)	1113.34**
Any invasive procedure use					
Invasive	5,308	132 (37.71)	2,637 (28.65)	2,521 (56.18)	973.906**

Note: Values in bracket represent percentages of patients. + indicates a multiple dichotomous variable meaning a patient can only have one of the procedure listed.
** $p < 0.01$.

number of non-Medicare patients were hospitalized in tertiary hospitals, for example, approximately 48% of patients other than Medicaid or Medicare and 39% of Medicaid patients were hospitalized in tertiary hospitals vs. 31% of Medicare patients.

Descriptive statistics of the patient variables concerning process of care are presented in Table 4. A chi-square test and analysis of variance were also used to compare differences among Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare. All the variables concerning process of care were found to be statistically significant suggesting significant differences in invasive procedure use among the three patient groups: Medicaid, Medicare, and patient other than Medicaid or Medicare. A greater number of patients other than Medicaid or Medicare received invasive treatment than Medicaid and Medicare patients. Among these three patient groups, patients other than Medicaid or Medicare received the most invasive procedures, while Medicare patients received the least.

For example, 56% of patients other than Medicaid or Medicare had invasive procedures, and 38% of Medicaid patients versus 29% of Medicare patients. Because of different techniques employed in invasive cardiac treatment and debates as discussed in Chapters II and III, it is of interest to understand how and whether each different invasive procedure is associated with patient outcome. A multiple dichotomous variable was then created to represent each type of invasive procedure use. Table 4 results show that patients other than Medicaid or Medicare were also the leading patient group in all types of invasive procedure use. It is interesting to note that Medicaid patients appeared to receive the least number of PTCA and CABG among the three patient groups.

In summary, the comparisons of Medicaid patients, Medicare patients, and patients other than Medicaid or Medicare demonstrate significant differences in patient demographics, clinical characteristics, hospital structural characteristics, and process of care. A further discussion of the differences in outcomes and process of care is presented later in this chapter.

To guide the selection of variables and reduce the number of variables in the model development, the following tables were generated to compare and display differences between AMI patients who survived and those who did not, and differences between AMI patients who had invasive procedures and those who did not. Because there were only two groups of patients in the analysis, a chi-square test for categorical variables and a t-test for continuous variables were used.

Table 5 summaries results of patient demographics. The chi-square and t-test results of these demographics are presented in Table 6. Significant differences were found for all demographic variables except residential area, suggesting significant demographic differences between patients who survived and those who did not, and differences between AMI patients who received invasive procedures and those who did not. The results in Tables 5 and 6 show that mortality greatly increased, and invasive procedure use sharply decreased with age. Female patients appeared to have significantly poorer outcomes, and received less invasive procedures than male patients. The results in Tables 5 and 6 again reveal a very small non-white patient population and significant racial differences for patient outcomes and invasive procedure use, although the significance of the racial difference was only at the .05 level for patient outcomes. Patients of Hispanic background seemed to have better outcomes, and Native American patients received more invasive procedures (although this may be a specious finding due to possible mis-coding problem for the race variable stated earlier in this chapter, and will be discussed later). In addition, the results in Table 5 show that Medicaid and Medicare patients had poorer observed mortality results than patients other than Medicaid or Medicare; for example, almost 9% of Medicaid patients and 15% of the Medicare patients died, while only 4% of indemnity plan patients, and 5% of managed care patients died. Medicare and Medicaid patients also received fewer invasive procedures in comparison with patients other than Medicaid or Medicare; for example, almost 38% of

Table 5

Demographic analysis by mortality result and invasive procedure use (N=14,041)

Demographic characteristics	Mortality results		Invasive procedure use	
	Survived	Died	Yes	No
	Number and percentage of patients			
All patients	12,457 (88.72)	1,584 (11.28)	5,290 (37.68)	8,751 (62.32)
Age groups				
18-40 years	322 (98.47)	5 (1.53)	200 (61.16)	127 (38.84)
41-54 years	1,878 (96.80)	62 (3.20)	1,149 (59.23)	791 (40.77)
55-64 years	2,238 (95.03)	117 (4.97)	1,228 (52.14)	1,127 (47.86)
65-74 years	3,421 (89.39)	406 (10.61)	1,651 (43.14)	2,176 (56.86)
75-84 years	3,220 (83.35)	643 (16.65)	975 (25.24)	2,888 (74.76)
85+ years	1,378 (79.70)	351 (20.30)	87 (5.03)	1,642 (94.97)
Gender				
Female	5,261 (86.10)	849 (13.90)	1,874 (30.67)	4,236 (69.33)
Male	7,196 (90.73)	735 (9.27)	3,416 (43.07)	4,515 (56.93)
Race				
Native American	32 (84.21)	6 (15.79)	36 (94.74)	2 (5.26)
Asian	40 (90.91)	4 (9.09)	17 (38.64)	27 (61.36)
Black	287 (90.82)	29 (9.18)	126 (39.87)	190 (60.13)
Hispanic	211 (94.62)	12 (5.38)	102 (45.74)	121 (54.26)
White	11,887 (88.58)	1,533 (11.42)	5,009 (37.32)	8,411 (62.68)
Type of Insurance coverage				
Medicaid	320 (91.43)	30 (8.57)	132 (37.71)	218 (62.29)
Medicare	7,503 (85.12)	1,312 (14.88)	2,502 (28.38)	6,313 (71.62)
Medicare MC	347 (89.20)	42 (10.80)	135 (34.70)	254 (65.30)
Other government	110 (94.83)	6 (5.17)	65 (56.03)	51 (43.97)
Free Care	147 (98.66)	2 (1.34)	65 (43.62)	84 (56.38)
Self pay	329 (94.27)	20 (5.73)	161 (46.13)	188 (53.87)
Indemnity	1,569 (95.79)	69 (4.21)	961 (58.67)	677 (41.33)
MC plans	2,132 (95.39)	103 (4.61)	1,269 (56.78)	966 (43.22)
Residential location				
Boston MSA	9,850 (88.78)	1,245 (11.22)	4,169 (37.58)	6,926 (62.42)
Non-Boston MSA	2,607 (88.49)	339 (11.51)	1,121 (38.05)	1,825 (61.95)

	Mean value			
Age	68.43	76.56	63.33	72.98

Note: Values in bracket represent percentages of patients. MC stands for managed care. Non-Boston stands for Non-Boston Metropolitan Service Area (MSA).

Medicaid patients and 28% of Medicare patients received invasive procedures, while 59% of indemnity plan patients, and 57% of managed care patients received invasive procedures. Medicare patients appeared to have the poorest observed mortality results and received the least number of invasive procedures among all AMI patients included in the analysis.

Table 6

Test results for mortality and invasive procedure use (N=14,064)

Demographic characteristics	Mortality results Chi-square /F value	Invasive procedure use Chi-square /F value
Age groups	504.88**	1758.28**
Gender	73.85**	226.01**
Race	10.41*	60.24**
Type of Insurance coverage	327.94**	1009.92**
Residential location		
Non-Boston MSA	0.19	0.23
Age	1.69**	1.10**

Note: Non-Boston stands for Non-Boston Metropolitan Service Area (MSA).
** $p < 0.01$, * $p < .05$.

Table 7 presents clinical characteristic differences between patients who survived and those who did not, and differences between AMI patients who received invasive procedures and those who did not. A chi-square test was used in the analysis and the results are presented in Table 8. All clinical characteristic variables were found to be statistically significant, except prior CABG for the dependent variable of mortality results, and diabetes, uncomplicated, for the dependent variable of invasive procedure use. These findings suggest significant clinical characteristic differences between patients who survived and those who did not, and differences between AMI patients who received invasive procedures and those who did not. The results in Tables 7 and 8 show that patients with emergency admissions

Table 7

Clinical characteristic analysis by mortality result and invasive procedure use (N=14,041)

Clinical characteristics	Mortality results		Invasive procedure use	
	Survived	Died	Yes	No
	Number and percentage of patients			
ER admission	7,693 (86.95)	1,155 (13.05)	1,838 (20.71)	7,016 (79.29)
Transfer	3,041 (93.08)	226 (6.92)	2,890 (88.46)	377 (11.54)
AMI location+				
Anterior	3,195 (85.04)	562 (14.96)	1,503 (40.01)	2,254 (59.99)
Inferior	3,145 (90.01)	349 (9.99)	1,584 (45.33)	1,910 (54.67)
Site other	756 (68.11)	354 (31.89)	126 (11.35)	984 (88.65)
Subendocardial	5,565 (93.58)	382 (6.42)	2,167 (36.44)	3,780 (63.56)
Other clinical characteristics+				
Complete atrioventricular block	231 (71.30)	93 (28.70)	86 (26.54)	238 (73.46)
Congestive heart failure	4,560 (83.30)	914 (16.70)	1,406 (25.69)	4,068 (74.31)
Chronic liver disease	68 (76.40)	21 (23.60)	16 (17.98)	73 (82.02)
Chronic renal failure	630 (82.03)	138 (17.97)	147 (19.14)	621 (80.86)
Diabetes, complicated	597 (84.80)	107 (15.20)	222 (31.53)	482 (68.47)
Diabetes, uncomplicated	1,719 (90.38)	183 (9.62)	697 (36.65)	1,205 (63.35)
Hypertension	4,787 (92.66)	379 (7.34)	2,214 (42.86)	2,952 (57.14)
Hypotension	867 (76.19)	271 (23.81)	300 (26.36)	838 (73.64)
Other major cerebrovascular disease	4,212 (87.35)	610 (12.65)	1,430 (29.66)	3,392 (70.34)
Late effects of cerebrovascular disease	11,890 (88.39)	1,562 (11.61)	5,168 (38.42)	8,284 (61.58)
Mitral disorder, rheumatic valve disorders, aortic valve disorders, heart valve replacement	869 (91.28)	83 (8.72)	197 (20.69)	755 (79.31)

Primary neoplasm of GI, respiratory, melanoma				
	88 (73.33)	32 (26.67)	20 (16.67)	100 (83.33)
Pulmonary edema, adult respiratory distress syndrome				
	346 (57.38)	257 (42.62)	160 (26.53)	443 (73.47)
Epilepsy, convulsions				
	234 (77.74)	67 (22.26)	65 (21.59)	236 (78.41)
Shock				
	17 (39.53)	26 (60.47)	4 (9.30)	39 (90.70)
Chronic skin ulcer				
	106 (77.37)	31 (22.63)	21 (15.33)	116 (84.67)
Anterior infarction and late effects of cerebrovascular disease				
	527 (92.13)	45 (7.87)	356 (62.24)	216 (37.76)
Prior CABG				
	32 (86.49)	5 (13.51)	31 (83.78)	6 (16.22)

Note: Values in bracket represent percentages of patients. + indicates a patient can have multiple clinical characteristics present.

Table 8

Test results for mortality and invasive procedure use (N=14,041)

Clinical characteristics	Mortality results Chi-square value	Invasive procedure use Chi-square value
ER admission	75.10**	2934.12**
Transfer	81.00**	4676.53**
AMI location+		
Anterior	69.31**	11.86**
Inferior	7.77**	116.22**
Site other	511.56**	355.69**
Subendocardial	243.25**	6.72**
Other clinical characteristics+		
Complete atrioventricular block	100.58**	17.50**
Congestive heart failure	262.93**	549.31**
Chronic liver disease	13.57**	14.80**
Chronic renal failure	36.30**	118.86**
Diabetes, complicated	11.37**	11.91**
Diabetes, uncomplicated	6.06*	0.99

Hypertension	127.08**	93.46**
Hypotension	194.33**	67.50**
Other major cerebrovascular disease	13.75**	201.16**
Late effects of cerebrovascular disease	34.98**	75.33**
Mitral disorder, rheumatic valve disorders, aortic valve disorders, heart valve replacement	6.70**	125.43**
Primary neoplasm of GI, respiratory, melanoma	28.63**	22.75**
Pulmonary edema, adult respiratory distress syndrome	618.27**	33.31**
Epilepsy, convulsions	37.04**	33.87**
Shock	104.25**	14.79**
Chronic skin ulcer	17.80**	29.42**
Anterior infarction and late effects of cerebrovascular disease	6.95**	153.21**
Prior CABG	0.19	33.59**

Note: + indicates a patient can have multiple clinical characteristics present.
** $p < 0.01$, * $p < .05$.

had poorer outcomes, and received fewer invasive procedures than those without emergency admissions. Transferred patients appeared to have better outcome results, and received more invasive procedures. The data also show that patients with an AMI location as anterior, or site other, had poorer outcomes than patients with an AMI of any other location. Patients with an AMI location as site other, received fewer invasive procedures. As for other clinical characteristics, the results show that patients with complete atrioventricular block, hypotension, primary neoplasm of GI, pulmonary edema, epilepsy, shock, or chronic skin ulcer present, had a tendency for poorer outcomes. Patients with hypertension, late effects of cerebrovascular disease, prior CABG, or both anterior infarction and late effects of cerebrovascular disease present, seemed to receive more invasive procedures. Late effects of cerebrovascular disease appeared to be the most prevalent diagnosis among the AMI patients included in the study.

Table 9 compares and displays hospital characteristic differences between patients who survived and those who did not, and differences between AMI patients who received invasive procedures and those who did not. The values in Table 9 represent typical average hospital characteristics by patient mortality results and invasive procedure use, for example, a mean volume of AMI patients of 557.39 and 494.04 for patients who survived and those who did not, respectively, means that for patients who survived, they were typically hospitalized in the hospitals which, on average, cared for about 557 AMI patients versus 494 patients for patients who did not survive. The values were computed by generating mean values of

Table 9

Hospital characteristics by mortality result and invasive procedure use (N=69)

Hospital characteristics	Mortality results: Survived	Died	F Value	Invasive procedure use: Yes	No	F Value
			Mean value			
Skills						
No. of invasive procedures/hospital	2204.67	1725.50	1.08	3869.36	1111.63	1.01
Volume of AMI patients/hospital	557.39	494.04	1.01	769.84	417.50	1.10**
Structural characteristics						
Investment in PPE (in billions)	0.21	0.18	1.13**	0.33	0.13	2.09**
Hospital size						
No. of operating beds	366.85	341.53	1.03	471.21	299.18	1.52**
Total no. of FTEs	2199.06	1925.40	1.08	3209.58	1538.67	1.70**
Nurse per bed	1.30	1.22	1.12**	1.51	1.16	1.05
No. of registered nurses	505.17	446.94	1.06	718.79	365.50	1.66**
			Number and percentage of patients			
Tertiary status						
Yes	4,665 (91.27)	446 (8.73)		3,709 (72.57)	1,402 (27.43)	
No	7,792 (87.26)	1,138 (12.74)	52.42**	1,581 (17.70)	7,349 (82.30)	4167.03**

Note: Values in bracket represent percentages of patients. PPE stands for gross plant, property and equipment. ** p < 0.01.

hospital characteristics among patients who survived; patients who did not survive; patients who received invasive procedures; and patients who did not receive any invasive procedure. A chi-square test was used for categorical variables and a t-test for continuous variables. No hospital skills variables were found to be statistically significant for patient mortality results, but hospital volume of AMI patients was found to be significant for invasive procedure use. Among the hospital structural characteristic variables, hospital investment and tertiary status were the only two variables found to be statistically significant for both patient mortality outcome results and invasive procedure use. Nurse per bed was found to be significant for

mortality outcome, but insignificant for invasive procedure use, while the number of operating beds, full time equivalents (FTEs), and registered nurses were found to be statistically significant for invasive procedure use, but insignificant for mortality results. The results in Table 9 show that patients who had poorer outcomes tended to be hospitalized in hospitals which had lower mean values in almost all the hospital characteristics, for example, patients who had adverse outcomes were hospitalized in the hospitals with an average nurse per bed ratio of 1.22, and 0.18 billion dollars of investment in PPE, versus 1.30 and 0.21 billion dollars for patients who survived AMI. Not surprisingly, these hospital characteristic differences seemed to be even greater for patients who received invasive procedures and those who did not. For example, patients who received invasive procedures were hospitalized in the hospitals with an average nurse per bed ratio of 1.51, and 0.33 billion dollars of investment in PPE, versus 1.16 and 0.13 billion dollars for patients who did not receive any invasive procedure, since only hospitals with investment in advanced cardiac technology can perform and provide invasive procedures. Table 9 also shows that tertiary hospitals had better observed mortality outcomes and performed a greater number of invasive procedures than non-tertiary hospitals, for example, approximately 9% of patients in tertiary

Table 10

Process of care variables by mortality result (N=14,041)

Process of care	Mortality results: Survived	Mortality results: Died	Chi-square Value
	Number and percentage of patients		
Types of invasive procedure use+			
Coronary angiography	1,753 (94.50)	102 (5.50)	
Percutaneous translumina coronary angioplasty (PTCA)	2,144 (96.58)	76 (3.42)	
Coronary artery bypass graft surgery (CABG)	1,062 (94.82)	58 (5.18)	
PTCA and CABG	88 (92.63)	7 (7.37)	
Non-invasive procedures	7,410 (84.68)	1,341 (15.32)	384.96**
Any Invasive procedure use			
Invasive	5,047 (95.41)	243 (4.59)	379.29**

Note: Values in bracket represent percentages of patients. + indicates a multiple dichotomous variable meaning a patient can only have one of the procedure listed.
** $p < 0.01$.

hospitals had poorer outcomes versus 13% of patients in non-tertiary hospitals; and 73% of the patients in tertiary hospitals received invasive procedures versus 18% in non-tertiary hospitals.

Comparisons on differences concerning process of care between patients who survived and those who did not are presented in Table 10. A chi-square test was used in the analysis. All variables were found to be statistically significant, suggesting significant differences in process of care between patients who survived and those who did not. The results in Table 10 show that patients who survived more often received invasive procedures than those who did not survive. Over 15 % of patients who did not receive any invasive procedure died, while only 5% of patients who received invasive procedures died. Among all types of invasive procedure use, PTCA seemed to be the most used invasive procedure, and had the best mortality results; almost 97% of patients who underwent PTCA survived and 3% did not.

In summary, the comparisons between patients who survived and those who did not, and between AMI patients who had invasive procedures and those who did not, suggest significant differences in not only patient demographics and clinical characteristics, but also hospital structural characteristics and process of care. Most of the variables suggested in the literature were found to be statistically significant in the analysis.

Data Reduction

A Pearson correlation was conducted to test for multicollinearity among each domain of the independent variables and to assure no selection biases of the independent variables. All the variables from the above tables that were to be considered in the models were tested. No pair of variables were found to have a high correlation coefficient, for example, $r >= 0.80$ except the following pairs of variables in the hospital characteristic domains: the number of registered nurses*total number of full time equivalents ($r=0.99$); the number of registered nurses*number of operating beds ($r=0.95$); the number of operating beds*total number of full time equivalents ($r=0.94$); the number of invasive procedures performed by hospitals*total number of full time equivalents ($r=0.91$); the number of hospital AMI patient volume*total number of full time equivalents ($r=0.87$); the number of invasive procedures performed by hospitals*total number of registered nurses ($r=0.88$); the number of hospital AMI patient volume*total number of registered nurses ($r=0.85$); the number of invasive procedures performed by hospitals*the number of hospital AMI patient ($r=0.92$); the number of invasive procedures performed by hospitals*tertiary hospital status ($r=.80$); the number of invasive procedures performed by hospitals*investment in PPE ($r=.82$); and investment in PPE*nurses*total number of full time equivalents ($r=0.94$).

Because of the multicollinearity tendency among these hospital structural characteristic variables, several solutions to multicollinearity were considered including using ratios, factor analysis, and dropping variables. Because of the high correlation between the

number of registered nurses and the number of operating beds, a variable of nurse per bed was formed using the number of registered nurses divided by the number of operating beds to measure hospital size and nurse resource allocation. The literature review in Chapter II also supported the variable of nurse per bed.

Extensive factor analysis was also attempted in an effort to correct multicollinearity and improve the model specification. Factor analysis is a statistical device often used as a solution to the multicollinearity problem (Maddala, 1977). It provides a data reduction method to combine many correlated variables into a small number of underlying dimensions and thus reduce the number of variables used in the model. However, with numerous tests and analyses, factor analysis failed to reveal clear-cut underlying dimensions or form useful variables. As a result, no meaningful interpretations could made on the results of the factor analyses, which led to the decision to drop variables and a choice to be made of hospital structural characteristic variables to be included in the models. Based on the literature review, the theoretical framework, policy relevance, and regression analysis results, four variables were eventually selected to represent hospital structural characteristics and skills. These four variables include: hospital AMI volume, investment in PPE, nurse per bed, and hospital tertiary status. However, the choice of these four variables and dropping other potential relevant hospital structural characteristics and skill variables due to the multicollinearity problem may result in biased parameter estimates of the hospital structural characteristics, skill variables, and inconsistent findings with the literature, which will be further discussed in the sections on model results.

Model Development

Over fifteen models were developed to explain the mortality results of AMI patients and the use of invasive procedures among AMI patients. Theory and previous empirical research suggested a large number of variables that belong in the models. However, it is necessary to develop models with a reduced number of variables that not only best explain patient outcomes and invasive procedure use, but also are of policy relevance so that the information is helpful to decision makers, and ultimately practice and policy recommendations can be made to improve patient outcomes. The selection of variables included in the logistic regression analysis was based on theory and prior empirical research, and on results of data analyses discussed earlier in this chapter. The following is a discussion about the development of the two models in the present study.

Patient Mortality Outcome Model

About 45 independent variables were initially considered and entered in the logistic regression. It was possible to pair this variable list down by a few variables as they were statistically insignificant and lacked literature support. The variables of: diabetes, uncomplicated; diagnosis of both anterior infarction and late effects of cerebrovascular disease; other major cerebrovascular disease; and chronic skin ulcers were dropped upon

closer examination. The variable of non-Boston MSA was not found to be statistically significant (p=0.4336) and subsequently was also dropped out of the model. Exclusion of these variables did not affect the overall performance of the model. Variables concerning race, type of insurance coverage, hospital characteristics, or AMI location variables were kept in the model even though some were found to be statistically insignificant. A full model with all remaining variables was then determined. Numerous reduced models were compared to the full model to determine the most parsimonious model that predicts patient mortality outcomes. To reduce the number of variables, tests of other forms of variables that might better explain the outcome variables were performed. For example, not all types of insurance coverage were significant in the outcome model, so categories that were not significant, but were compatible, were then combined. The variables used in the final Outcome Model (see Appendix D) were: Medicaid patients, Medicare patients, uninsured patients, and patients of other government payers, with private-payer patients covered under commercial health plans as the base group. A model that contained fewer variables but did not reduce substantially the concordance or increase substantially the Akaike information criterion, Schwarz criterion and log-likelihood was considered as an improvement over the full model. The results of the initial and full logistic regression model on patient outcomes are presented in Appendix C. Results from the final Outcome Model are shown in Appendix D.

Where invasive procedure use was first introduced in the model as a binary variable (INVASIVE) to test the hypothesis that invasive procedure use influences patient outcomes, the final model results (see Appendix D) show that invasive procedure use is significantly associated with patient outcomes (p=.0001). The parameter estimate of the variable is negative and the odds ratio of 0.32 suggests that a patient who had an invasive procedure had a higher odds of dying than a patient without any invasive procedure. The difference in the odds of invasive procedure use between the patients was almost 68%. This key finding led to the question as how each specific type of invasive procedure is associated with patient outcomes. In other words, do all types of invasive procedures improve patient outcome? As discussed in Chapter II, there have been debates in the literature on the use of aggressive heart procedures and the effects of these procedures on patient outcomes (Berwick, 1994, Mark, et al. 1994, Udvarhelyi, et al. 1992; Winslow, et. al., 1988). To investigate and understand the relationships between each specific type of invasive procedure use and AMI patient outcomes, multiple dichotomous variables representing each specific type of invasive procedure use were entered in the final Outcome Model. These variables include: coronary angiography; PTCA; coronary artery bypass graft surgery; a combination of both PTCA and bypass surgery; and no invasive procedure, with patients who had no invasive procedures as the base group. The results of the final model with these specific invasive procedures as multiple dichotomous independent variables are presented in appendices F and G.

Patient Process Model

Forty-three variables were initially considered and entered in the logistic regression. Several insignificant variables were dropped upon close examination. These variables

included: diabetes, uncomplicated; hypertension; and diagnosis of pulmonary edema, adult respiratory distress syndrome. Exclusion of these variables did not affect the overall performance of the model. A full model with all remaining variables was then determined. Although several variables concerning the location of AMI were noticeably insignificant, for example, anterior wall and inferior infarction, they were kept in the model because the location of AMI is thought to be important for intervention decisions to be made in practice. So were the hospital attributes. Numerous reduced models were also compared to the full model to determine the most parsimonious model. To reduce the number of variables, tests of other forms of variables that might better explain the outcome variables were also performed, for example, not all types of insurance coverage were significant in the outcome model, so categories that were not significant but were compatible were combined. The variables used in the final process models were: Medicaid patients; Medicare patients; Medicare managed care patients; uninsured patients; and patients of other government payers; with private-payer patients covered under commercial plans as the base group. The results of the initial and full logistic regression for the patient process model are presented in Appendix H. The final process model results are shown in Appendixes I and J.

Model Results

Final models explaining patient outcomes and invasive procedure use were determined, and results are presented in Appendixes D and I. The Response Profile table gives the ordered value of the dependent variables. In the patient outcome model, patients who did not survive were ordered value 1, and patients who did were ordered value 2. The process models had ordered value 1 for the patients who had an invasive procedure, and ordered value 2 for the patients who did not.

All the models regressed with SAS LOGISTIC procedure were found significant (p=.0001). The measure of the overall model significance is -2 log Likelihood. A significant chi-square p-value of the 2-Log likelihood statistics provides evidence that at least one of the regression coefficients is not zero. The AIC (Akaike information Criterion) and the SC (Schwarz Criterion) are adjusted -2 log likelihood scores based on the number of independent variables and the number of the cases used in the model. They are often used as a goodness-of-fit measure in comparison of one model to another. Lower values of the AIC and SC typically indicate a more desirable model (SAS Institute, 1995). In addition, a receiver operating characteristic also called ROC curve was used as a measure of the predictive accuracy of the final models. The ROC for the final models are displayed in Appendix K. The sharp rise of the ROC curves and a large area under the ROC curves suggest the models have high predictive power (SAS Institute, 1995).

Parameter estimates give the estimated coefficients of the fitted logistic regression. A positive parameter estimate suggests a positive association between the variable and a patient's odds of dying or receiving an invasive procedure; and a negative parameter estimate indicates a negative association between the variable and a patient's odds of dying or

receiving an invasive procedure. Because it is difficult to interpret a parameter estimate, an odds ratio is typically used to simplify the discussion and interpretation of logistic regression results. An odds ratio greater than one means that a patient with that characteristic had a higher odds than a patient without such a characteristic to have a poor outcome, or receive an invasive procedure; and an odds ratio less than one means that a patient with that characteristic had a lower odds than a patient without such a characteristic to have a poor outcome, or receive an invasive procedure.

The Association of Predicted Probabilities and Observed Response table following the parameter estimates provides several quality measures of the logistic model. The concordance and discordance in the models report the percentages that the models correctly predict the true and false outcomes. The four indexes (Somers' D, Gamma, Tau-a, and c) are computed from the number of concordant and discordant pairs of observations. Higher values of these indexes in a model indicate that the model has better predictive ability (SAS Institute, 1995). The results of the final models are presented in Appendices D and I.

Patient Outcome Model

Discussion of the patient outcome model is based on the Final Outcome Model (see Appendix D). This model has private-payer patients as the base group. Some key results from other outcome models (see Appendices E and F), as well as the initial and full outcome models presented in Appendix C are also included. The other outcome models (see Appendix E) consisted of two models with patients of indemnity plans, and patients of managed care, respectively, as the base group. The model (see Appendix F) has multiple dichotomous variables for types of invasive procedures with private-payer patients as the base group. The difference between the Final Outcome Models (1) and (2) is the use of a dichotomous variable for any invasive procedure in the Final Outcome Model (1) versus multiple dichotomous variables for each specific type of invasive procedures in the Final Outcome Model (2). The concordance and discordance of the final outcome model are 81.9% and 17.7% suggesting additional and important variables have not been captured in the model and data set. However, variables in each domain were found to be significant and support the framework of the study.

Results of the logistic regression for patient outcomes identified nearly 25 significant predictors of patient outcomes. Variables found to have a significant and positive association with mortality at the 0.05 significance level are: age; being Native American; Medicare; emergency room admission; transfer; anterior infarction; complete atrioventricular block; congestive heart failure; chronic liver disease; chronic renal failure; diabetes complicated; hypotension; inferior infarction; late effects of cerebrovascular disease; primary neoplasm of GI; pulmonary edema; seizure; shock; infarction other or unspecified; hospital AMI patient volume; and tertiary hospital status. Variables found to have a significant and negative association with mortality at the 0.05 significance level are: the interactive variable of age and Medicare; hypertension; rheumatic valve disorders; investment in property; and invasive

procedure use. Being Hispanic was found to be marginally statistically significant, (p=0.1014) and associated with a lower odds of dying.

While much of the debate about quality of care has focused on improving access to health services, the outcome model results of the present study show that institutional characteristics and process of care are related to patient outcomes. Changes in these characteristics and process of care can make differences in improving the odds that a patient survives an AMI. The following is a discussion of each variable associated with patient outcomes.

Demographics (PATDEM)

Age:

Patient age was found to have a significant and positive association with patient mortality, suggesting older patients are more likely to have poor outcomes than younger patients. The odds ratio of 1.063 means that an increase in age of one year is associated with a 6.3% increase in the patient's odds of dying. This finding is consistent with previous studies on age and mortality (Franks, et al., 1996; Green, et al., 1990; Henning, et al., 1979; Leor, et al., 1993; Mark, et al., 1994; Naessens, et al., 1992; OSHPD, 1993).

Gender:

Gender was not found to be statistically significant at the 0.05 level (p=0.1432), but was positively associated with patient mortality controlling for patient characteristics, hospital characteristics, and process of care variables. An odds ratio of 1.09 suggests an a female patient has approximately a 9% higher odds of dying than a male patient. While significant gender difference has been noted in many studies (Franks, et al., 1996; Green, et al., 1990; Henning, et al., 1979; Leor, et al., 1993; Mark, et al., 1994; Naessens, et al., 1992; OSHPD, 1993), the present study is consistent with the study by Udvarhelyi, et. al. (1992) which found no significant gender difference in 30-day survival among AMI patients; and the study by Ritchie, et. al. (1993) which concluded that female sex was not predictive for AMI patient mortality.

Race/ethnicity:

None of the race/ethnicity variables were found to be statistically significant at the 0.05 level except Native American, which appeared to be associated with higher mortality. The odds ratio of 2.934 suggests Native American patients had almost 3 times the odds of dying compared to white patients. These findings on race, however, are largely consistent with previous studies (OSHPD, 1993; Mark, et al., 1994).

Being Hispanic was found to be marginally statistically significant at the 10% level (p=0.1014), but surprisingly had a negative association with patient outcomes. An odds ratio of 0.586 suggests an almost 40% difference in the odds of dying between Hispanic and white patients, with Hispanic patients more likely to survive than white patients. Black and Asian

patients also tended to have lower mortality than white patients, but this finding was statistically insignificant, and therefore these outcome differences were inconclusive in the present study. However, the finding of an outcome difference between black and white people appeared to be consistent with an earlier study by Udvarhelyi, et al. (1992), which concluded a reverse pattern of racial difference between black and white patients in 30 day survival: black patients had slightly better survival at 30 days than did white patients.

Race/ethnicity variables were found to be most problematic in this study. For example, a noticeably very low percentage of black (2%) and Hispanic people (nearly 2%) were in the study population, suggesting that race/ethnicity represented in the study population was either mis-coded or under-reported for non-white population, in particular, for black and Hispanic population. Cardiovascular disease is known to be much more prevalent in the black community than in any other community (Douglas, http://www.uvm.edu/~vdouglas/project.htm), as are the risk factors for heart disease, e.g. smoking, cholesterol, and being overweight. In addition, according to the population estimates for 1995-2000 by the U.S. Bureau of the Census (1995), black and Hispanic populations were 6.14% and 5.85% respectively of the total state population in Massachusetts in 1995. Therefore, it is doubtful that the low percentage of black population included in the analysis is representative of the black population in Massachusetts.

However, the validity of race concept itself seems questionable. According to a study by LaVeist (1994), race is a poorly understood concept and because of lack of definition and clarity, many quantitative models that attempt to explain race differences are inadequate to inform health or social policy. Examining how race has been used in 192 articles published in Health Services Research between 1966 and 1990, a study by Williams (1994) found race used in 63% of the articles examined to stratify or adjust results, and as a proxy for broad categories, ranging from socioeconomic status such as poverty, education, and income, to discrimination and skin color. There is obviously an inappropriate use of race as a variable in the literature. It is impossible to assess how the use of race as variable to adjust patient mortality outcomes influences the results of the present study, because it is unknown how hospitals or patients report race in the FIPA. However, it is likely that race reported in the FIPA was not standardized across hospitals, given the lack of definitions and the measurement problems associated with race. Given all the limitations and the problematic concept of race, one must exercise caution in interpretation of any results related to race and ethnicity.

Type of Insurance coverage:

These variables are one of the primary focuses of the study. They provide answers to the question whether Medicaid and Medicare patients have the same quality of care as those of private-payer patients. The model results showed that Medicaid and Medicare patients were more likely to suffer from adverse outcomes than private-payer patients, although the difference between Medicaid and private-payer patients was not found to be statistically significant at the 0.05 level (p=0.0654). However, Medicaid patients were found to have

significantly poorer outcomes at the 0.05 level than those patients of indemnity plans in both initial and full outcome models (see Appendix C).

A further analysis of the Final Outcome Model (presented in Appendix E), with patients of indemnity plans as the base group, also confirmed that Medicaid patients had significantly poorer outcomes than patients of indemnity plans. An odds ratio of 1.73 suggests Medicaid patients had nearly twice the odds of poorer outcomes than patient of indemnity plans, controlling for all other factors that might influence patient outcomes. A similar finding was noted in a previous study by Young and Cohen (1992) at the Massachusetts Department of Public Health (DPH). In addition, when managed care patients were used as the base group, the parameter estimate for Medicaid patients remained positive (indicating higher mortality), but not statistically significant (see Appendix E). This suggests that Medicaid patients might be more likely to have poorer outcomes than managed care patients. The odds ratio of 1.41 means a 41% difference in the odds of dying between Medicaid and managed care patients.

Like Medicaid patients, Medicare patients also appeared to have significantly poorer outcomes than private-payer patients, controlling for all other factors. In order to further control for the fact that Medicare patients are significantly older, an interactive term between age and Medicare was entered in the model. Medicare patients and the interactive variable of age and Medicare patients were found to be significant at the 0.05 level. Medicare patients had a greater odds of poor outcome, while the interactive variable was negatively associated with the outcome. The odds ratio of 8.988 for Medicare patients and 0.972 for the interactive variable between age and Medicare patients, suggests that Medicare patients had a higher odds to have poorer outcomes than private-payer patients, but the odds difference gradually diminished when patients were older. In other words, the difference between younger Medicare patients and private-payer patients is greater than the difference between older Medicare patients and private-payer patients. For example, the outcome difference in terms of odds ratios between a 65 year-old Medicare patient and a private-payer patient was approximately 38%, and 22% between a 85 year-old Medicare patient and a private-payer patient. However, it is worth noting that the outcome difference between Medicare and private-payer patients may be biased due to lack of younger than 65 year-old Medicare patients, or over 65 year-old Medicaid, or patients insured other than by Medicaid or Medicare. In the present study population, approximately 5.6% of Medicare patients were under 65 years and 12% of patients insured other than by Medicaid or Medicare were over 65 years. Although the models developed controlled for age differences, it is likely that other differences between Medicare and non-Medicare patients might not be captured in the present study.

Patients of other government payers were also found to have poorer outcomes than private-payer patient, but the finding was not statistically significant. The difference in the odds of dying between patients of other government payers and private-payers was approximately 7%. Surprisingly, uninsured patients had an odds ratio of 0.993 indicating a

marginally better odds to have better outcomes than private-payer patients, but the finding was not statistically significant either. Although uninsured patients are more likely experience poor outcomes than insured (Davis, K., 1997), this present study cannot provide any conclusive evidence on uninsured patients. Perhaps, the free care pool which the Commonwealth administrates to redistribute financial resources among hospitals allows hospitals to allocate adequate resources to uninsured individuals. For those self-paid patients, one hypothesis is that they were discharged before they died; or that they died prior to their arrival at hospitals.

As for managed care patients, they were entered in the initial and full patient outcome models (see Appendix C) as well as the final outcome models (see Appendixes E and G), in which patients of indemnity plans were the base patient group. All these model results showed parameter estimates with a positive association with poor outcome, suggesting a managed care patient might have a poorer outcome than a patient of an indemnity plan. The odds ratios for managed care patients in the models ranged from 1.22 to 1.24, meaning managed care patients had approximately 22% to 24% higher odds of mortality than patients of indemnity plans. However, none of the findings between managed care patients and patients of indemnity plans were statistically significant at the 0.05 level (p values ranged from 0.2066 to 0.2475). Therefore, it is inconclusive from this present study that managed care patients had poorer outcomes than patients of indemnity plans. However, managed care patients appeared to be associated with better outcomes than Medicaid or Medicare patients when managed care patients are entered as base patient group in Final Outcome Model (see Appendix E) as discussed earlier.

Both Medicaid and Medicare patients were found to have poorer outcomes compared to managed care patients. Medicaid patients had an almost 41% higher odds of dying than managed care patients, although this finding for Medicaid patients was not statistically significant at the 0.05 level (p=0.1571). As for Medicare patients, the difference in the odds of dying between a 65-year old Medicare patient and a 65-year-old managed care patient was approximately 26%. These findings seem to indicate that perhaps shifts of Medicaid and Medicare patients into managed care may be an option to improve patient outcomes for Medicaid and Medicare patients. A further outcome study of Medicaid and Medicare patients with managed care plans is recommended.

Clinical characteristics (CLINICAL)

Emergency admission:

Patients with emergency admissions were found to have a significant and positive association with poorer outcomes. The odds ratio of 1.215 suggests an approximately 22% difference in the odds of dying between patients with emergency admission and those without emergency admission. The significant finding is consistent with a previous study (OSHPD, 1993).

Transfer:

Transfer patients were also found to have a significant and positive association with poor outcomes. The odds ratio of 1.682 suggests a 68% higher odds of mortality for transfer patients compared to non-transfer patients. The literature review for this study provided little insight into why a transfer patient would have a much higher odds of dying than an non-transfer patient. One hypothesis could be delay in treatment.

Location of AMI:

Variables concerning the location of AMI appeared to be strong predictors of outcomes. Anterior wall site, inferior wall site, and other or unspecified site were, found to be significantly and positively associated with poor outcome. The odds ratio were 2.862, 1.996, and 5.070, respectively, suggesting greater differences in the odds of dying between patients with these locations of AMI and those without such locations of AMI. However, subendocaredial location of an AMI was not found to be statistically significant.

Other clinical characteristics:

All other clinical characteristics were found to be statistically significant at the 0.05 level, except prior CABG, which was marginally significant (p=0.0592). Other clinical characteristics found to be associated with higher odds of mortality included complete atrioventricular block, congestive heart failure, chronic liver disease, chronic renal failure, diabetes complicated, hypotension, late effects of cerebrovascular disease, primary neoplasm of GI, pulmonary edema, seizure, and shock. In other words, patients with these clinical characteristics present were more likely to die than those without such clinical characteristics present. Hypertension and rheumatic valve disorders were the only two other clinical characteristics that were found to have negative associations with mortality, meaning patients with these two clinical characteristics had lower odds of dying than those without such characteristics controlling for all other factors associated with the outcome. These findings appear to be consistent with previous studies (DeBusk, et al., 1983; Gillum, et al., 1983; Gwilt, et al., 1985; Mark, et al., 1994; McClellan, et al., 1994; Pozen, et al., 1984; OSHPD, 1993; Zehender, et al., 1993). Among these clinical variables, chronic liver disease, hypotension, late effects of cerebrovascular disease, primary neoplasm of GI, pulmonary edema, seizure, shock, and prior CABG, which all had odds ratios nearly or above 2, were considered as stronger predictors that increase the odds of poor outcomes.

Hospital experience (SKILLS)

AMI patient volume:

The AMI patient volume that a hospital experienced was found to have a significant and positive association with higher mortality. The odds ratio of 1.376 indicates that for every 1,000 more AMI patients a hospital cared, the patients' odds of dying would increase by almost 38%. In other words, the more AMI patients a hospital cared for, the worse outcome result a hospital had, which seems to be a troubling finding. Although the finding provides evidence that hospital experience is related to patient outcomes, the positive

association with poorer outcomes appears to depart from the previous literature (Hanna, et al., 1989; Luft, et al., 1979; Mark, et al., 1994.; McClellan, et al., 1994).

There may be several explanations for the above finding. First of all, there might be lack of sufficient controls for patient risk and severity of illness for hospitals with a high volume of AMI patients, given the data limitations discussed further in the next chapter. Because some important variables may be left out in the outcome model, parameter estimates of the variables including the AMI patient volume may be biased. Secondly, as discussed earlier in this chapter, the multicollinearity among hospital characteristic variables might result in biased estimates of the variables related to hospital characteristics. Finally, the AMI patient volume might not be a good measure for hospital experience and skills. Other variables, for example, specialty and clinical experience of attending physicians who care for the AMI patients, may be better measures of providers' experience and skills. However, such information is unavailable from the data used in the present study.

Hospital structural characteristics (HOSPSTRU)

Investment in PPE:

Investment in PPE was not found to be statistically significant, but was negatively associated with mortality. The odds ratio of 0.968 suggests that more investment in PPE might improve patient outcome. One billion dollar increase in PPE decreases the patient odds of dying by approximately 3%. The insignificant finding of the present study is not consistent with the study by Samuel Levitt (1994), who found a correlation between investment in PPE and confirmed failure rates of Generic Quality Screen used by a Peer Review Organization (PRO) based on data from 87 hospitals in Massachusetts, and concluded that investment drives quality of care. Perhaps the statistical inconsistence is due to a methodological difference. The present study takes into consideration differences in patient risk and severity of illness, hospital characteristics, and process of care which were not controlled in the Levitt study. Another possible reason may have to do with the measurement of hospital investment itself. Gross investment in plant, property and equipment (PPE) used in the present study measures a hospital's total investment in overall PPE, which may or may not reflect that the hospital invested in equipment and technology for cardiac invasive diagnosis or therapeutic procedures. In fact, not all hospitals in Massachusetts have invasive cardiac treatments available. Therefore, direct investment in equipment and technology for cardiac invasive diagnosis or therapeutic procedures may be a better predictor for AMI patient outcome. However, such information cannot be obtained from the data source available.

Nurse per bed:

The variable of nurse per bed was not found to be statistically significant, but did have a negative association with outcome. The odds ratio of 0.946 suggests that an increase in nurse per bed ratio might improve patient outcome. One unit increase in nurse per bed ratio decreases the patient odds of dying by approximately 5%. Like the variable of

investment in PPE, the statistically insignificant finding could also be the result of insufficient controls for patient risk and severity of illness, or multicollinearity among hospital characteristics.

<u>Tertiary status</u>:

Tertiary status was found to have a significant and positive relationship with poor outcomes. The odds ratio of 1.336 suggests an almost 34% higher odds of mortality for patients in tertiary hospitals compared to those in non-tertiary hospitals. The literature review revealed inconsistent conclusions and findings on whether hospital type is associated with patient outcome. The study by Selker, et al. (1994) concluded that no hospital type was associated with significant differences between their actual and predicted mortality rates based on six New England hospitals. The study also concluded that urban teaching hospitals had a higher predicted mortality rate. Yet, the study by Stephen Shortell and colleagues (1994) found that hospitals with significantly higher profits and involvement in teaching appeared more likely to invest more in technology, which, in turn, was associated with lower mortality.

Like the hospital variables previously discussed, there may be several explanations for the finding about tertiary hospitals in the present study, and the inconsistence with the literature review. First of all, parameter estimates of tertiary hospital status might be biased due to lack of sufficient controls for patient risk and severity of illness given the data limitations discussed further in the next chapter. Secondly, the multicollinearity among hospital characteristic variables might result in the biased estimate of the tertiary hospital variable. Thirdly, as discussed in Chapter IV, the arbitrary classification of tertiary hospitals due to lack of consensus on the definition of Massachusetts tertiary hospitals might also be responsible for the above finding. Finally, the inconsistence in literature might be due to methodological differences and sampling among the studies. The present study controls for patient risk and severity, hospital characteristics, and differences in patient process of care. Sixty-nine acute hospitals in Massachusetts were included in the present study with a total 14,041 AMI patients, where as prior studies had smaller samples.

Process of care variables (PROCESS)

<u>Any invasive procedure use</u>:

Invasive procedure use was found to be significantly and negatively associated with patient outcome in the outcome model, suggesting invasive procedure use was related to patient survival. The Final Outcome Model (see Appendix D) shows an odds ratio of 0.32, meaning approximately a 68% difference in the odds of dying between a patient receiving an invasive procedure and a patient not receiving any invasive procedure. This finding provides evidence that invasive procedure use makes a difference in patient outcomes. Furthermore, it demonstrates a significant association between process of care and outcome of care. Improvement in process of care can lead to better patient outcomes.

Type of invasive procedure use:

All types of invasive procedure use were found to have significant and negative associations with mortality, based on the Final Outcome Model (see Appendix F) in which multiple dichotomous variables representing different types of invasive procedures were entered. Odds ratios for coronary angiogrpahy, PTCA, CABG, and the use of both PTCA and CABG are 0.404, 0.235, 0.306, and 0.348. This means that patients who received these invasive procedures had approximately 60%, 76%, 69% and 65% better odds of survival than those who did not receive any invasive procedures. PTCA appeared to be associated with the biggest difference in terms of the patient odds of survival among these invasive procedures, as it had the lowest value for the odds ratios.

The interpretation of these invasive procedures also deserves caution due to a possible selection bias from both doctors and patients in terms of giving and accepting invasive interventions. For example, doctors might be more likely operate on those patients who, they believed, based on their judgement, were more likely to survive an AMI. As a result, patients whose future looked gloomy to doctors might not be given invasive treatment. The data in the present study show that only 15% of the patients who died received invasive procedures. Similarly, invasive procedure use could also be determined by a patient or his/her family. As a result, a patient might not accept or undergo invasive procedure treatment, against a doctor's judgement, and consequently had a poorer outcome. Therefore, the findings about invasive procedure use might be biased, although it is impossible to know how such a selection bias impacted the present study.

In summary, the study results suggest not only patient demographics and clinical characteristics are associated with outcome, but also institutional characteristics and process of care variables. Changes in institutional characteristics and improvement in process of care can lead to better patient outcomes. Although the study cannot provide conclusive evidence on two key institutional characteristics (investment and nurse per bed), findings support the proposed model which suggests institutional characteristics and process of care variables can influence patient outcomes when differences in patient characteristics are controlled. The finding about tertiary hospitals suggests, however, that the actual type of patient care received may make more of a difference in patient outcome than the characteristics of the institution. The outcome findings on Medicaid, Medicare, and managed care patients are particularly meaningful and useful to both Medicaid and Medicare programs which are encouraging managed care enrollment. While managed care patients were found to have higher mortality than patients of indemnity plans in the present study, they had lower mortality than Medicaid and Medicare patients not enrolled in managed care (although the finding was statistically insignificant for Medicaid patients). This suggests that increased managed care enrollment of Medicaid and Medicare beneficiaries may lead to better patients outcomes.

Hospital Mortality Outcome Results

Table 11 shows the observed and predicted mortality outcome results for hospitals using the Final Outcome Model (1) (see Appendix D). The first column is the identification number for hospitals included in the study. Each hospital was given a numerical number to be used as identification number to protect confidentiality of an individual hospital. The observed mortality outcomes in the second column were calculated by summing up adverse outcomes of each hospital during FY 1995. The very next column to the observed rates are the predicted mortality outcome results based on the study's model. The fourth and fifth columns contain predicted mortality results at the 95% lower confidence level and upper confidence level. The results in Table 11 demonstrate hospital differences in AMI mortality outcomes. Some hospitals had lower observed mortality outcomes than predicted, meaning better outcome results compared to their predicted outcomes, controlling for differences in patient characteristics, hospital characteristics, and process of care. For example, Hospital ID 14 had 17 observed deaths, less than the 27.45 predicted. Overall, 33 hospitals were found to have more observed deaths than predicted, meaning these hospitals might have poorer outcome results; and 36 hospitals were found to have less or similar observed deaths than predicted, meaning these hospitals could have better or no worse outcome results. However, the hospital variance between observed deaths and predicted appeared to vary by hospitals. For some hospitals, the variance between observed deaths and predicted was small, for example, Hospital ID 5 had 17 observed deaths vs. 17.45 predicted; for some hospitals, the variance between observed deaths and predicted appeared larger, for example, Hospital ID 34 had 13 observed deaths vs. 22.89 predicted. A further analysis of the variance follows.

Table 11

Hospital observed versus predicted mortality (N=69)

ID	Observed	Predicted	LCL	UCL
1	22	21.66	16.65	28.11
2	7	8.11	6.50	10.03
3	29	31.73	25.99	38.19
4	49	47.93	38.85	58.67
5	17	17.53	14.31	21.46
6	30	26.93	21.82	33.11
7	6	9.34	7.51	11.46
8	16	14.10	11.71	16.87
9	35	35.56	28.65	43.65
10	25	17.37	13.94	21.45
11	31	28.84	21.03	39.33
12	13	14.78	12.04	18.09

13	8	9.36	7.29	11.82
14	17	27.45	22.74	32.73
15	20	16.41	12.93	20.93
16	26	23.65	19.53	28.51
17	18	20.95	17.29	25.21
18	6	5.39	4.52	6.41
19	18	16.44	13.94	19.25
20	24	20.68	17.36	24.47
21	8	12.12	9.75	14.96
22	20	21.88	18.02	26.36
23	15	17.34	13.68	21.93
24	7	8.71	6.98	10.81
25	25	29.48	23.24	36.89
26	33	37.19	29.77	46.01
27	31	33.70	26.92	41.86
28	25	21.82	17.87	26.49
29	8	8.48	7.07	10.12
30	15	17.96	14.87	21.64
31	46	40.07	30.30	52.75
32	28	31.02	22.93	42.00
33	34	37.26	28.81	47.74
34	13	22.89	19.15	27.15
35	24	25.76	20.77	31.94
36	17	10.46	8.11	13.33
37	11	10.14	7.98	12.69
38	15	9.83	8.11	11.88
39	10	6.64	5.40	8.10
40	41	49.43	40.10	60.35
41	9	5.30	4.30	6.52
42	23	36.48	30.26	43.65
43	16	19.44	15.66	23.89
44	15	13.26	10.04	17.25
45	66	50.61	39.98	63.74
46	14	11.57	9.19	14.52
47	29	27.85	22.77	33.84
48	11	11.00	8.95	13.49
49	26	21.12	17.26	25.62

50	10	6.35	5.15	7.79
51	24	22.11	18.29	26.49
52	2	6.89	5.36	8.81
53	35	36.86	29.40	46.13
54	11	16.14	13.15	19.77
55	9	5.67	4.60	6.95
56	85	77.24	57.95	101.84
57	12	7.44	5.86	9.30
58	24	14.06	11.44	17.08
59	8	5.30	4.19	6.64
60	19	12.22	9.93	14.90
61	7	8.22	6.66	9.96
62	7	5.89	4.64	7.45
63	27	31.14	23.50	40.80
64	6	7.23	4.78	10.73
65	18	21.03	16.79	26.16
66	33	44.66	36.22	54.61
67	84	88.30	65.62	118.93
68	66	60.20	44.53	80.64
69	45	44.04	32.59	59.03

Note. Values represent number of deaths. LCL = lower confidence level; UCL = upper confidence level.

To analyze and compare variance of hospital outcome results, a variance ratio of hospital observed mortality results versus predicted mortality results was calculated using the number of hospital AMI mortality outcomes divided by the number hospital predicted outcomes presented in Table 11. The calculation can be expressed in the following equation:

Hospital ratio = hospital observed deaths / predicted deaths.

The ratios for the 69 hospitals included in the present study are presented in Table 12. The first and third columns are hospital identification numbers; the second and fourth columns are the ratios calculated using the above hospital ratio equation. The variance ratios in Table 12 show that the hospital variance between observed deaths and predicted ranges from 0.29 to 1.71, suggesting substantial outcome differences among hospitals. The mean hospital variance ratio was found to be 1.04 with a standard deviation of 0.29. Figure 2 on page 66 illustrates a graphic comparison in a bar and line graph. The bars represent hospital identification numbers and the mean hospital ratio; the lines represent 1 standard deviation above or below the mean hospital ratio. The comparison shows eleven hospitals with the

hospital variance ratios above one standard deviation of the mean hospital ratio, and eight hospitals with the hospital variance ratios below one standard deviation of the mean hospital ratio. It is important to further investigate those hospitals with the hospital variance ratios below and above one standard deviation of the hospital mean ratio, as well as those hospitals with the hospital variance ratios within one standard deviation of the hospital mean ratio so that a better understanding of outcome differences among hospitals can be developed. A further review of these hospitals revealed that all tertiary hospitals had their ratios within one standard deviation of the hospital mean ratio, while some non-tertiary community hospitals

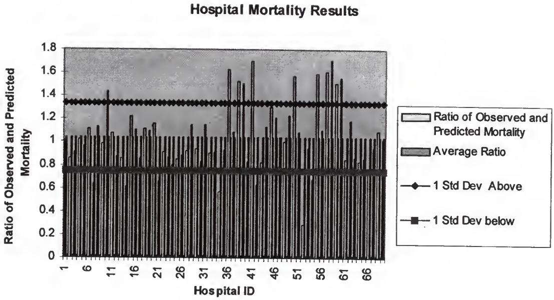
Table 12

Hospital variance of observed and predicted mortality outcomes

ID	Ratio	ID	Ratio	ID	Ratio
1	1.02	24	0.80	47	1.04
2	0.86	25	0.85	48	1.00
3	0.91	26	0.89	49	1.23
4	1.02	27	0.92	50	1.57
5	0.97	28	1.15	51	1.09
6	1.11	29	0.94	52	0.29
7	0.64	30	0.84	53	0.95
8	1.13	31	1.15	54	0.68
9	0.98	32	0.90	55	1.59
10	1.44	33	0.91	56	1.10
11	1.07	34	0.57	57	1.61
12	0.88	35	0.93	58	1.71
13	0.85	36	1.63	59	1.51
14	0.62	37	1.09	60	1.55
15	1.22	38	1.53	61	0.85
16	1.10	39	1.51	62	1.19
17	0.86	40	0.83	63	0.87
18	1.11	41	1.70	64	0.83
19	1.10	42	0.63	65	0.86
20	1.16	43	0.82	66	0.74
21	0.66	44	1.13	67	0.95
22	0.91	45	1.30	68	1.10
23	0.86	46	1.21	69	1.02

Note: Ratio stands for hospital variance ratio between observed deaths and predicted.

Figure 2



had their ratios above or below one standard deviation of the hospital mean ratio. Although all tertiary hospitals appeared to have their ratios within one standard deviation of the hospital mean ratio, their ratios did vary ranging from 1.15 to 0.83. Those community hospitals with their ratios above one standard deviation of the hospital mean ratio (meaning higher rates of observed versus predicted mortality) appeared to have a tendency to perform either a smaller number of invasive procedures or no invasive procedures; have a lower volume of AMI patients; and invest less in their PPE. For those community hospitals with their ratios below one standard deviation of the hospital mean ratio, they seemed to perform either a larger number of invasive procedures, or no invasive procedures; have a higher volume of AMI patients; and invest more in their PPE in comparison to those community hospitals with their hospital ratios above one standard deviation. These results imply that hospitals do differ in their outcomes of care. Outcome differences among community hospitals were in general larger than those of tertiary hospitals, while the differences among tertiary hospitals were relatively smaller.

There may be several explanations for these hospital results. First, patients' risk and severity might not be fully accounted for patients hospitalized in tertiary hospitals. Second, the community hospitals measured poorly did not provide adequate care to their patients, for example, patients who should have been given invasive interventions were not due to unavailability of invasive cardiac care. Third, the community hospitals measured well might have transferred more complex AMI cases to tertiary hospitals. Finally, other hospital characteristics and non-invasive treatments which might be responsible for patient outcomes

were missing from the outcome models. Therefore, a further study is needed to evaluate and validate the quality of these hospitals.

In summary, the hospital outcome results demonstrated mortality variations among hospitals controlling for patient and hospital characteristic differences, as well as patient differences in process of care. Hospitals were identified with better or poorer mortality outcome results. However, a further study is required to determined which institutional factors actually account for differences in hospital outcome results.

Patient Process Model

Logistic regression was used to model a dichotomous dependent variable of invasive procedure use, and the set of independent variables which might explain invasive procedure use. The concordance and discordance of the final logistic regression model presented in Appendix I are 89.8% and 10.1%, suggesting some additional variables are missing. Variables in each domain of the models which were found significant support the framework of the study that patient demographics, clinical characteristics, and hospital structural characteristics explain invasive procedure use.

Results of the logistic regression for invasive procedure use identify nearly 28 significant predictors of patient invasive procedure use at the 0.05 significance level. Factors found to have a significant and positive association with invasive procedure use are: age; Native American; Hispanic; the interactive variable between age and Medicare patients; late effects of cerebrovascular disease; prior CABG; nurse per bed; and tertiary hospital. Factors that have a significant and negative association with invasive procedure use are: Medicaid; Medicare; uninsured; living outside the Boston metropolitan area; emergency room admission; complete atrioventricular block; congestive heart failure; chronic liver disease; chronic renal failure; diabetes complicated; hypotension; primary neoplasm of GI; valve disorders; other major cerebrovascular disease; seizure; shock; infarction other or unspecified; and chronic skin ulcer. Having both anterior infarction site and late effects of cerebrovascular disease were found to be marginally significant ($p=0.0593$) but positively associated with invasive procedure use. While the literature review documented the sharp decrease of the use of angiography with age, and significant differences in procedure use on the basis of sociodemographic characteristics (Ayanian, et. al., 1991; Goldberg, et. al., 1992; Gornick, et. al., 1996; Steingart, et. al., 1991; Udvarhelyi, et al. 1992), the results of the present study suggested institutional characteristics were also related to invasive procedure use. It is worth noting that the variables concerning the location of AMI were not found statistically significant in predicting invasive procedure use.

The following is a discussion of each factor associated with the probability of invasive procedure use:

Demographics (PATDEM)

Age and age squared:

Patient age was found to be significantly associated with invasive process use. Age squared was entered to improve the model specification. The odds ratios of 1.27 and 0.998 for age and age squared, respectively, suggest that younger patients had a higher odds of receiving invasive procedures than older patients, and the odds difference in invasive procedure use become greater with age. For example, odds ratios were approximately 1.02, 0.97, 0.85, and 0.77, for patients at the age of 45, 55, 80, and 100 respectively, meaning patients at the age of 45 increased their odds of invasive procedure use by a factor of 2 % while patients at the age of 100 decreased their odds of invasive procedure use by a factor of 23%. This finding is consistent with a study by Udvarhelyi, et al. (1992), which concluded significant differences in the procedure use by age. Perhaps the decision on invasive procedure use was largely influenced by the perception or judgement that older patients were less likely to survive than younger patients, and therefore less interventions were given. It is also possible that older patients or relatives of the patients might not want to have interventions, and as a result these older patients were less likely to receive invasive procedures.

Gender:

Gender was found to have a negative association with invasive procedure use, which was statistically significant at the 0.10 level (p=0.0919), controlling for all other variables which might influence invasive procedure use. The odds ratio of 0.916 means an 8% difference in the odds of invasive procedure use between a female patient and a male patient, suggesting that women, in general, had a lower odds to receive invasive procedures than men. This finding is also consistent with the previous studies (Ayanian, et al., 1991; Udvarhelyi, et al., 1992) in which gender difference in procedure have also been noted. However, the gender finding was not highly significant in the present study.

Race/ethnicity:

All the race variables were found to statistically significant at the 0.05 level, except that for Asian patients. Native American and Hispanic patients had positive associations with invasive procedure use suggesting that these patients might be more likely to receive invasive procedures than white patients. The odds ratios for Native American patients and Hispanic patients were 12.658 and 1.424 respectively, meaning that Native Americans had almost 13 times the odds of invasive procedure use than white patients, and Hispanic patients had an approximate 42% higher odds of receiving invasive procedures than white patients. The literature review did not provide insight on the high odds ratios, in particular, for Native Americans with invasive procedure use. However, the problems of race and ethnicity discussed earlier with the outcome model might bias the findings on invasive procedure use for Native American and Hispanic patients. Black patients were found to have a significant and negative association with invasive procedure use, suggesting black people might had a significantly lower odds of receiving invasive procedures than white people. The odds ratio

of 0.69 means a 31% difference in the odds of invasive procedure use between black and white patients. This finding of black patients is consistent with a prior study by Goldberg, et. al. (1992) which concluded that black people were less likely to undergo CABG, and a prior study by Udvarhelyi, et al. (1992) which concluded that black people were less likely to undergo coronary angiography than white people. As for Asians patients, they were also found to have fewer invasive procedures controlling for all other variables. The odds ratio of 0.799 means an approximate 20% difference in the odds of invasive procedure use between Asian and white patients. However, as noted earlier, race variables were found to be most problematic in this study and results concerning race are, therefore, likely inconclusive and unreliable.

Type of insurance coverage:

Variables concerning insurance coverage are one of the primary focuses of the study. They provide answers to one of the hypotheses that insurance coverage is associated with invasive procedure use. The model results showed that patients insured by Medicaid and the uninsured had a significantly lower odds to receive invasive procedures than patients of private-payers. The odds ratios of 0.661 and 0.654 for Medicaid and uninsured patients respectively suggest a 34% and a 35% difference in the odds of invasive procedure use between Medicaid and private-payer patients, and between uninsured and private-payer patients. There may be several reasons for the difference. One might be due to the global inpatient reimbursement rate used by the Massachusetts Medicaid program regardless of procedure use. Another reason might have to do with patients' preferences or doctors' decisions as discussed earlier with the outcome model results. More Medicaid patients might choose not to under go invasive treatments while doctors might be more reluctant to give invasive procedures to Medicaid patients because of their severity of illness or lack of family support. Further studies are needed to understand why Medicaid patients receive less invasive procedures.

As for Medicare patients, the odds ratios of 0.041 for Medicare, and 1.053 for the interactive variable of age and Medicare patients, suggest that younger Medicare patients had a lower odds of receiving invasive procedures than private-payer patients, while older Medicare patients seemed to have a higher odds of receiving procedures than private-payer patients. For example, the odds ratios for a Medicare patient at the age 65 and 80 were 1.19 and 2.60, respectively, suggesting a 19% difference in the odds of invasive procedure use between a 65 year-old Medicare patient and a private-payer patient, and an almost two and half times difference in the odds of invasive procedure use between an 85 year-old Medicare patient and a private-payer patient.

A further analysis revealed that difference in invasive procedure use between Medicare and private-payer patients depended on the model specification. When the interactive variable of age and Medicare was dropped out of the process model presented in Appendix L, Medicare patients were found to be significantly at the 0.05 level, and positively associated with invasive procedure use, suggesting Medicare patients had a significantly

higher odds to have invasive procedure use. An odds ratio of 1.163 means an approximate 16% difference in the odds of invasive procedure use between Medicare and private-payer patients. However, as previously discussed with the outcome model results, any results about Medicare patients might be biased due to lack of Medicare patients under the age of 65 and non-Medicare patients over 65. The process model with the interactive variable of age and Medicare presented in Appendix I is preferred because it had a better model specification given the lower -2 Log L Score.

Because of access concerns, controversies about, and public interest in managed care in the past few years, especially intensive media attention about the restriction and authorization process of HMOs for high cost procedures (Clement, et al., 1994; DeMaria, et al., 1994; Knox, 1997; Manning, et. al, 1984; Pham, 1996; Safran, et al., 1994), managed care patients and the interactive variable between age and managed care patients were entered in the final process model (see Appendix J) with patients of indemnity plans as the base group. The odds ratios of 2.838 and 0.981 for managed care patients and the interactive variable between age and managed care patients, respectively, suggest that younger managed care patients had a higher odds of receiving invasive procedures than patients of indemnity plans, while older managed care patients had a lower odds of receiving invasive procedures, controlling for patient and hospital characteristics. For example, the odds ratios are approximately 1.58, 1.30, 1.00, and 0.88, respectively, for a managed care patient at the age of 30, 40, 53, and 60. This finding indicates that younger managed care patients might not necessarily have access barriers to high cost procedures, but older managed care patients might, compared to patients of indemnity plans. As for patients covered by other government payers, they were found to have a higher odds to receive invasive procedures, but the finding was not statistically significant.

Residential area:

Patients living outside the Boston Metropolitan Service Area (MSA) were found to have a significantly lower odds of receiving invasive procedures. The odds ratio of 0.83 suggests a 27% difference in the odds of invasive procedure use between patients living in the Boston MSA and patients outside the Boston MSA. This indicates a possible access barrier to acute cardiac invasive treatment as fewer hospitals outside the Boston MSA perform invasive procedures. Patients living outside the Boston MSA may have to be transferred to other hospitals to receive invasive treatment.

Clinical characteristics (CLINICAL)

Emergency admission:

Patients with emergency admissions were found to have a significant and negative association with invasive procedure use suggesting a lower odds of invasive procedure use for patients with emergency admission. The odds ratio of 0.261 means an approximate 74% difference in the odds of invasive procedure use between patients with emergency admissions and those without emergency admissions.

Location of AMI:

None of the AMI location variables was found to have a significant or negative association with invasive procedure use except infarction site as other or unspecific. The odds ratio of 0.388 suggests an almost 61% difference in the odds of invasive procedure use between patients with infarction site as other or unspecific, and patients without such an infarction present. All other AMI location variables appeared to increase the odds of invasive procedure use. However, they were not statistically significant at the 0.05 level. Yet, these location variables of AMI were significant predictors of AMI outcomes in the patient outcome model.

Other clinical variables:

Other clinical characteristics that were also found to have a significant and negative association with invasive procedure use at the 0.05 level include: complete atrioventricular block; congestive heart failure; chronic liver disease; chronic renal failure; diabetes complicated; hypotension; other major cerebrovascular disease; valve disorders; primary neoplasm of GI; seizure; shock; and chronic skin ulcer suggesting these variables are associated with less invasive procedure use. Late effects of cerebrovascular disease, an interactive variable of anterior infarction site and late effects of cerebrovascular disease, and prior CABG, were the only three other clinical characteristic variables found to have a significant and positive association with invasive procedure use, although the interactive variables of anterior infarction and late effects of cerebrovascular disease were found to be marginally significant at the 0.05 level ($p=0.0593$). Late effects of cerebrovascular disease and prior CABG with odds ratios greater than three were considered as strong predictors that significantly increase invasive procedure use.

Hospital structural characteristics (HOSPSTRU)

Investment in PPE:

Investment in PPE was not found to be statistically significant, but had a positive association with invasive procedure use. The odds ratio of 1.087 suggests that more investment PPE might increase the patient odds of receiving an invasive procedure, controlling for patient characteristics and other hospital characteristics. One billion dollar increase in PPE increases the patient odds of having invasive procedure use by almost 9%. As discussed earlier in the outcome model results, the insignificant finding of investment might be due to insufficient controls of patients' risk and severity, the multicollinearity among hospital characteristics, or measurement error of the variable.

Nurse per bed:

Nurse per bed was found to be statistically significant and had a positive association with invasive procedure use suggesting that hospitals with a higher nurse per bed ratio tend to use invasive procedures more frequently. The odds ratio of 5.57 means that a one unit increase in nurse per bed ratio increases a patient's odds of having invasive procedure use by over five times. This finding provides evidence that hospital characteristics are associated

with process of care. However, as discussed earlier in the outcome model results, the finding could be the result of insufficient controls for patient risk and severity of illness, the multicollinearity among hospital characteristics, or measurement error.

Tertiary status:

Tertiary status was also found to have a significant and positive relationship with invasive procedure use, suggesting patients in tertiary hospitals were much more likely to receive invasive procedures than non-tertiary patients, controlling for patient characteristics and other hospital characteristics. The odds ratio of 4.239 suggests that a patient in a tertiary hospital had four times the odds of receiving an invasive procedure than a patient in an non-tertiary hospital. This is perhaps due to the availability of the services. A study by Blustein (1993) found that the availability of invasive cardiac services strongly influenced patients' likelihood of procedure use. This finding of the present study again provides evidence that hospital characteristics are associated with process of care.

In summary, the study results suggest that not only are patient demographics and clinical characteristics associated with process of care, but also institutional characteristics. Changes in structure of care can improve process of care, which, in turn, can improve patient outcomes through their influences on process of care. Although the study cannot provide conclusive evidence about hospital investment, the results are in the predicted direction. The invasive procedure findings for Medicaid, Medicare and managed care patients are again particularly meaningful and useful to both Medicaid and Medicare programs. Medicaid patients were found to receive significantly fewer invasive procedures than private-payer patients, but Medicare patients, in general, received more invasive procedures than private-payer patients (although younger Medicare patients did seem to receive fewer invasive procedures). Enrollment of Medicaid beneficiaries in managed care plans may increase invasive procedure use among Medicaid patients. However, enrollment of Medicare beneficiaries in managed care may decrease their receipt of invasive procedures.

Indirect Effects of Being a Medicaid or a Medicare Patient on Outcome

The results of patient outcome and process models suggested significant differences in outcome and invasive procedure use among patients, particularly between Medicaid patients, Medicare patients, and patients of private-payers. It is of interest to investigate indirect effects of being a Medicaid and a Medicare patient on outcomes. The present study examined the indirect affects of being a Medicaid or a Medicare patient on outcomes due to their influence on process of care.

Prior to the calculation of the indirect effects, the total and direct effects had to be estimated. The present study used the following procedures for calculating the total, direct, and indirect effects of a factor, either being a Medicaid or a Medicare patient, on outcomes. In fact, any factor, such as a patient demographic characteristic, or a hospital characteristic, that was entered in the process model has an indirect effect on mortality by its influence on

the probability of having an invasive procedure. If the factor is also entered in the outcome model, it has a direct effect on outcome as well. The direct effect is the amount by which the mortality outcome is associated with the factor, if invasive procedure use were held constant as the factor varied. The indirect effect is the amount by which the mortality outcome is affected only by the difference in invasive procedure use as the factor varies. The total effect is the sum of the direct and indirect effects. The total effect also includes an interaction between the direct and indirect effects, but since this is small, it was included in the calculation of the direct effect.

In order to calculate these effects for a factor, call the baseline level B, and the alternative level A. For example, in the case of being a Medicaid or a Medicare patient, the baseline level B might indicate the patient belonged to the reference group, say a private-payer patient, and the alternative level A would indicate the patient was Medicaid or Medicare.

The total effect can be calculated as the probability of dying given A, minus the probability of dying, given B.

$$\text{(1)} \quad \text{Total Effect} = \Pr(\text{dying} \mid A) - \Pr(\text{dying} \mid B).$$

Each of these probabilities involves evaluating both the process and outcome equations of the models. The steps are as follows. First, estimate the probability of having an invasive procedure given A by evaluating the procedure equation. Call the event "getting an invasive procedure" "I", and the event "not getting an invasive procedure "not I".

$$w1=\Pr(I \mid A).$$

Second, estimate the patient probability of dying given A by:

$$\Pr(\text{dying} \mid A) = w1 * \Pr(\text{dying} \mid A, I) + (1-w1) * \Pr(\text{dying} \mid A, \text{not } I).$$

This probability is the weighted average of the probabilities of dying conditional upon whether or not the patient gets an invasive procedure, where the weights are the probabilities of getting the invasive procedure or not. Next, do the same for the baseline, B:

$$w2=\Pr(I \mid B)$$

$$\Pr(\text{dying} \mid B) = w2 * \Pr(\text{dying} \mid B, I) + (1-w2) * \Pr(\text{dying} \mid B, \text{not } I).$$

Then the total effect is given by (1) above. The expected mortality probability of 0.11 and 0.04 were the total effect calculated for a Medicaid and Medicare patient, respectively, assuming the patient had the following characteristics presented by variable values in Table 13.

To calculate the indirect effect of dying due to different procedure usage for A and B, calculate the probability of dying that A would have if A received an invasive procedure with the same probability as B. Call this Pr(dying | A, I (B)):

$$Pr(dying \mid A, I(B)) = w2*Pr(dying \mid A, I) + (1-w2)*Pr(dying \mid A, not\ I).$$

Next, calculate the indirect effect as the difference in the probability that A would die, depending on whether or not they receive an invasive procedure with their own probability, or instead with B's probability.

(2) Indirect Effect = Pr(dying | A) - Pr(dying A, I(B)).

The indirect effect for a Medicaid or Medicare patient was calculated as approximately 0.02 and -0.01, which suggests a 2% and -1% difference in patient expected mortality probability, respectively, between a Medicaid and private-payer patient; and between a Medicare and private-payer patient due to the indirect effect of being a Medicaid or a Medicare patient through their influence on process of care. Finally, the direct effect is just the difference between the total effect given by (1), and the indirect effect given by (2):

(3) Direct Effect = Total Effect - Indirect Effect

The direct effect of being a Medicaid and a Medicare patient was found to be approximately 0.10 and 0.06, meaning a 10% and 6% difference, respectively, in patient expected mortality probability between a Medicaid and a private-payer patient; and between a Medicare and a private-payer patient. This enforces that the direct and indirect effects add to the total effect.

(4) Total Effect = Direct Effect + Indirect Effect

These results show the outcome differences are primarily due to the direct effects of being a Medicaid or a Medicare patient. The indirect effects of being a Medicaid or a Medicare patient through their influence on process of care are relatively modest but were partially responsible for the outcome differences. Furthermore, the result of indirect effects indicate a possible under-use of invasive procedures for Medicaid patients, as an approximate 2% difference in patient mortality probability was due to less invasive procedure use for Medicaid patients. Although the impact of the indirect effect appeared to be modest, it has implications for policy making. In the case in which a patient's life is at stake, such an impact can make a life or death difference. For Medicaid patients, since the poorer outcomes were partially a result of poorer process of care due to being Medicaid patients, policy changes within the Medicaid program, establishment of stricter standards of process of care for Medicaid patients, or continuing to shift patients to managed care may be needed to improve Medicaid patient outcomes.

Table 13

Values used in calculating the indirect effects of being a Medicaid or a Medicare patient on outcome

	Medicaid	Private-payer	Medicare	Private-payer
VARIABLES	A1	B1	A2	B2
CAGE	45	45	65	65
AGESQ	2025	2025	4225	4225
FEMALE	1	1	0	0
NATIVE	0	0	0	0
ASIAN	0	0	0	0
BLACK	0	0	0	0
HISPANIC	0	0	0	0
MCDPAY	1	0	0	0
MCRPAY	0	0	1	0
AMCRPAY	0	0	65	0
OGVMTPAY	0	0	0	0
UNINSUD	0	0	0	0
NONBMSA	0	0	0	0
TRANSFE	0	0	0	0
ADMIERRM	1	1	0	0
ANTERIOR	1	1	0	0
ATRIBLK	0	0	0	0
CHF	1	1	0	0
CHRLIVER	0	0	0	0
CHRRENAL	1	1	0	0
DIABETCM	1	1	1	1
HYPER2	0	0	0	0
HYPO	0	0	1	1
INFERIOR	0	0	0	0
OTHCEREB	0	0	1	1
LATECVA	1	1	1	1
OTHVALVE	0	0	0	0
PULEDEMA	0	0	0	0
PRIMALIG	0	0	0	0
SEIZURE	1	1	0	0
SHOCK	0	0	0	0
SITE_OTH	1	1	1	1
SKNULCER	0	0	0	0
SUBENDO	0	0	0	0
COMBO4	1	1	1	1
PRCABG	0	0	0	0

HOSPAMIV	2	2	2	2
GROPPE95	0.5	0.5	0.5	0.5
NURSEBED	1.5	1.5	1.5	1.5
TERTIARY	1	1	1	1

Note: A1 and A2 represent Medicaid and Medicare patients; B1 and B2 represent private-payer patients.

As for Medicare patients, the result of the indirect effect show a somewhat different picture. The indirect effect of being a Medicare patient actually decreases the patient mortality probability by approximately 1% through its influence on process of care (meaning more invasive procedure use for Medicare patients), but the influence is too small to narrow the mortality gap between Medicare patients and private-payer patients. This suggests that the direct effect of being a Medicare patient is a stronger predictor of mortality than the indirect effect through more invasive procedure use. Further studies are needed to explore other differences that may explain the outcome variation between Medicare patients and private-payer patients; and other differences due to insurance coverage that may indirectly influence outcomes through process of care.

CHAPTER 6

DISCUSSION AND POLICY IMPLICATIONS

This concluding chapter discusses and addresses the implications of the study's findings. Potential health policy options and recommendations and their impact on patient outcomes are presented. This chapter also includes a discussion of limitations of the study. Finally, areas for future research are discussed and proposed.

Conclusions and Recommendation

The results of the study demonstrated variations in hospital mortality results and a number of factors that were significantly associated with patient outcomes and process of care. Consistent with the conceptual model and the framework proposed in the present study, these factors, in particular those of hospital characteristics and process of care, were found to be significantly associated with patient outcomes. The results of the study also revealed that a number of variables were significantly associated with invasive procedure use. The findings suggest that the outcome model has utility in providing important new insight on AMI patient mortality outcome and should be adopted in the other outcomes. The study has also demonstrated the value of using administrative data sets to conduct outcome research, however, improvements in these data sets would make them even more useful. The significant findings of the study suggest a number of different options to improve patient outcomes and invasive procedure use.

First, based on the study results and key findings, Medicaid and Medicare programs should monitor quality of care that their beneficiaries receive and intervene if necessary to ensure quality of care for their beneficiaries. This should include not only investigating outcomes of care, but also structure and process of care. There have been several Medicaid and Medicare quality monitoring and improvement projects established. The Division of Medical Assistance in Massachusetts has set and implemented specific quality goals for the Medicaid population for the past few years. Continuing efforts in educating providers about high risk populations have been made throughout the Medicaid system and in managed care organizations. However, simply educating providers may not be sufficient.

Consistent with a study on Massachusetts's Medicaid patients by Young and Cohen at the Department of Public Health (1992), this present study showed poorer Medicaid patient outcomes again, controlling for patient characteristics, hospital characteristics and process of care. In addition, the study showed significantly poorer process of care for Medicaid patients, controlling for patient characteristics and hospital characteristics, which, in turn, led to poorer outcomes. This may in part be due to current reimbursement practices, however, perhaps, it is time for the Medicaid program to rethink its strategies in improving quality of care for its population. Based on the study results, one option is to consider an outcome-driven reimbursement system for Medicaid and Medicare patients. The traditional health

reimbursement system does not reward quality providers or punish bad providers. From the reimbursement perspective, there is little incentive for providers to act on patient outcomes, or to improve Medicaid or Medicare patient outcomes. If the Medicaid and Medicare programs reimburse providers based on their Medicaid and Medicare patient outcomes, and reward quality providers with financial incentives, providers will be more apt to improve patient outcomes. This option is recommended because it is an essentially performance and market driven system, which has been used in many other industries. For example, the quality revolution in automobile industry has led to a more competitive and consumer-friendly U.S. market of today.

Another option is to improve Medicaid and Medicare patient outcomes and process of care through selective hospital contracting. With this option, the Medicaid and Medicare programs would contract services only with hospitals that have proved to have quality of care for Medicaid and Medicare patients. However, this option may add additional access barriers for Medicaid and Medicare patients, especially in the areas outside the Boston MSA where the availability of invasive cardiac treatments may be limited.

Enrollment of beneficiaries in MCOs (Managed Care Organizations) may also improve quality of care for the Medicaid and Medicare population. Although the present study failed to conclude that managed care patients, in general, had better outcomes controlling for patient characteristics, hospital characteristics, and process of care, the study provided strong evidence that managed care patients did not have poorer outcomes than patients insured by other payers, and they had a significantly better process of care than Medicaid patients.

The Massachusetts Division of Medical Assistance is currently actively pursuing this. The goal is to have multi-year contracts with MCOs and move all the beneficiaries into MCOs. It is estimated that over 300,000 Medicaid eligibles are expected to enroll in MCOs by year 2000 (Division of Medical Assistance, 1997). Long-term contracts have major advantages over short-term contracts and have been used by private health care purchasers with HMOs. According to BNA managed care reporter (1997), besides the traditional rate guarantees, long-term contracts allow HMOs, providers and employers to develop partnerships for healthier members and stability. They provide incentives for HMOs and providers to implement more preventative programs, and continuously improve member and patient health status. They also provide members with stability of providers so that they do not have to change doctors due to changes of health plans.

A recent unique three-year contract between PacficCare, one of the largest HMO based in California, and two of California's largest health care purchasers-the California Public Employees Retirement System and the Pacific Business Group on Health, specified that the rate increase under the contract was tied to PacfiCare's ability to make enrollees healthier (BNA Managed Care Reporter, 1997), which suggests an essentially outcome oriented contract, and supports the recommendation of an outcome-driven reimbursement

system for Medicaid and Medicare. However, given the high risk population covered by Medicaid and Medicare, and the complexity of health care services required by the individuals, whether MCOs can provide comprehensive coverage and have expertise in servicing a large population of Medicaid and Medicare enrollees while maintaining medical costs remains to be seen. HMO Blue, one of the largest leading heath plans in Massachusetts just recently announced to drop coverage of 41,000 Medicaid members by July, 1998 due to financial losses (Pham, 1998). The Medicaid and Medicare programs need to continue to monitor MCO care and evaluate the results of such care.

Second, providers should rethink how they care for individual patients. The study revealed age, insurance coverage, and other socio-demographic differences which were particularly apparent in process of care. This study found older patients tended to have poorer outcomes and less invasive procedure use; Medicaid patients and Medicare patients, had poorer outcomes; and Medicaid patients also received fewer procedures than those of private-payer patients, while Medicare patients seemed to received more invasive procedure controlling for other patient and hospital differences. Providers should be alerted to these individual differences and take actions to meet the needs and experiences of high risk populations. It is impossible to know from these data how and whether providers consider socio-demographic differences among patients in their care. However, the data do show that changes are needed to improve patient outcomes, particularly among high risk populations: older, Medicaid, and Medicare patients. As pointed out by Berwick, "Without a clear focus on the needs and experiences of individual patients, much of the financial and structural reorganization now rampant in health care will be unlikely to yield improvements that matter to the patients we serve" (Berwick, 1996).

Thirdly, based on the hospital mortality results, providers should rethink how they can improve the quality of care. Some hospitals appeared to have better mortality results and some appeared to have poorer results. Because of the multicollinearity problem among the hospital characteristics, the study could not provide conclusive evidence on how these hospitals characteristics influence their outcomes. But hospitals can gain a better understanding of their structural differences if they get together and share their information. Further, it is more important that hospitals work together for the well-being of patients, instead of working against each other to compete for patient volume. Those hospitals measured poorly should be alarmed and learn from the hospitals measured well. A regionaliztion of AMI acute care may result in improvement of patient outcomes.

Fourth, providers cannot act alone in improving patient outcomes. Patients' well-being and care depend on a spectrum of participants including providers, insurers, families, patients, and society in general. Improvements throughout the spectrum would result in greater improvement in patient care and outcomes. A national policy to prevent heart disease, for example, including anti-smoking, healthy eating habits, and exercise campaigns; and routine blood pressure, and cholesterol testing, are also likely to improve the health and the economic well-being of society in many aspects. Multi-year contracts can help in

development of partnership among MCOs, providers, purchasers, and enrollees to improve patients' health status and preventative care use. In fact, facing rising medical costs and difficulties in controlling costs, leading MCOs now realize that they must improve the health status of the population in order to ultimately reduce the medical cost of their enrollees. These MCOs have recently begun to get together and work with providers and communities to improve the health status of the population in Massachusetts, which will make it possible for all providers, employers, insurers, and payers to succeed financially, and for patients to benefit from quality of care and more importantly to enjoy quality of life.

Finally, public release of outcome measurement information will likely motivate changes in providers. Several states have already experienced such changes since the public release of the information, e. g. California and New York. Providers will have to learn from best practices and share information in order to survive the outcome competition, and patients will be able to choose providers with the information. The New York state cardiac surgery program is an example of how the information can help patients to make a choice of treatment and an informed health care decision. The program provides cardiac surgical mortality results by surgeon so that prospective patients can be informed about the results of their prospective surgeons. The health care market will prevail as consumers' choices as well as purchasers' shape market competition which maximizes the efficiency of resource allocation. However, measurement is not a goal or the end result by itself, but a tool. It should be used to further the improvement of patient care which is the ultimate mission of any measurement.

Limitations

There are several limitations that should be discussed here. One limitation of this study lies in the FIPA, a hospital administrative data base collected primarily for the purpose of health care reimbursement. Despite its availability, accessibility and low cost, the data set may lack in-depth, patient-pertinent clinical information compared to medical records. A study by Jollis et al. (1993) on the suitability of claims for use in outcome research in ischemic heart disease found that agreement rates between the clinical and claim database ranged from 0.83 for the diagnosis of diabetes, to 0.09 for the diagnosis of unstable angina. The study concluded that insurance claims data lack important diagnostic and prognostic information when compared with concurrently collected clinical data in the study of ischemic heart disease. Although the agreement rates are unknown in the case of acute myocardial infarction in the present study, it is evident that some patients' diagnostic and prognostic information are missing from the claims data used in the present study due to limited number of secondary diagnoses available in the FIPA, e.g. the ST-segment elevation in lead V_{4R}. Prior research by Zehender et al (1993) concludes that patients with ST-segment elevation in lead V_{4R} had a higher in-hospital mortality rate. Exclusion of these presumably relevant risk factors may bias parameter estimates. In addition, the administrative database had no ability to distinguish between comorbidities and complications (Hannan, et al., 1997). Because

complications may reflect the quality of care, misuse of complications as risk predictors may bias the study results.

Another limitation of this study has to do with the problem of acute myocardial infarction coding. There was a lack of criteria for acute myocardial infarction, and lack of standardization in data collection (Gillum, et al, 1984). To evaluate the appropriateness of the diagnostic coding of acute myocardial infarction, Iezzoni et al. (1988) studied this problem and its implications using a random sample of hospital admissions assigned a discharge diagnosis of acute myocardial infarction between October 1984 and September 1985 from five tertiary teaching, five other teaching, and five non-teaching hospitals, in metropolitan Boston. Iezzoni et al. found that 260 of the 1,003 cases reviewed did not meet the clinical criteria for acute myocardial infarction, and 175 of the cases reviewed failed to qualify at tertiary hospitals, compared with 25 at non-teaching hospitals. This finding has implications for any researchers who use the hospital discharge abstracts for the purpose of hospital outcome measurement in terms of interpretation and reliability of study results.

Because of the concern about coding, the researcher contacted Mass PRO, a not-for-profit organization with which HCFA contracts to review Medicare discharges. The review includes ICD-9-CM patient diagnosis. Mass PRO typically conducts a sample review of Medicare discharge claims by hospital on annual basis. According to Mass PRO, coding of Medicare claims is generally accurate and hospitals devote resources to coding accuracy. Although the magnitude of the problematic acute myocardial infarction coding with the patients included in this study is unknown, particularly for those non-Medicare patients, it is likely that this study is subject to a coding bias. Therefore, caution will be needed in interpreting the findings of the study.

Inability to account for patients' preferences/decisions or doctors' choices/ decisions about their treatment is another limitation. For example, bypass surgery decisions are up to patients and doctors. Clearly AMI patients' preferences/decisions as to medical treatments can determine their outcomes. However, such information is unavailable because it is not collected in the FIPA, although patients' preferences affect hospitals' mortality rates. Currently little literature documents the impact of patients' decisions on clinical outcome. This applies to doctors too, who may choose not to operate on patients unlikely to survive. However, the present study provided an example as to the extent to which such an administrative data set can contribute to understanding of quality of care and patient outcome information.

There might be a hospital selection bias that the study failed to recognize. A study by Miller, et al. (1994) on variation in practice for discretionary admissions, using state-level data from the HCFA Medicare hospital information report, found that selection bias arising from variation in admission practice causes the expected mortality rate to be overestimated for all hospitals, but especially for those hospitals with more lenient admission practices. The study concluded that variation in admission practice will cause any outcome measure based

solely on hospitalized patients to be biased. However, it is impossible to estimate the selection bias due to differences in admission practice in the present study or to correct such a bias, as no data on those un-hospitalized AMI patients were available across hospitals. Selection bias could also arise from patients' selection of hospitals. Some patients might choose the hospitals in which they would receive care while others did not. For example, urban tertiary hospitals may be more likely to attract and serve patients of lower social economic status, and therefore, may have higher risk patients compared to suburban community hospitals. Such bias could also result in biased measures of patient outcomes.

There is also another data limitation that might bias the study results. Because the FIPA did not have unique patient identifiers in FY 1995, it was impossible to identify patients with a coronary angiography who might undergo invasive procedures in a following hospitalization. Further, the multicollinearity problem among hospitals characteristic variables is an issue. Although factor analysis was attempted and variables highly correlated were dropped, the parameter estimates of hospital variables may be biased. Therefore, any results of hospital characteristics must be interpreted with caution.

Finally, this study is limited to short-term inpatient outcomes and invasive procedure use only. It does not include other important outcome measures such as patient functional status, satisfaction, or non-invasive cardiac treatment. Thus, the proposed study results can reflect only one aspect of patient care. Further studies of a spectrum of outcome measures, including patient long-term survival, functional status, and non-invasive procedure use are needed to complement short-term mortality outcome measures. In addition, conclusions about individual hospital quality cannot be drawn simply based on one outcome measure (AMI mortality), overall quality will need to be measured using several different types of outcome measures.

Areas for Future Research

All of the limitations discussed above should be improved upon in future work. Acute myocardial infarction will continue to be a major public health concern. Research will be needed to evaluate whether prevention efforts, individualized care, hospital structure changes, or outcome-oriented reimbursement improve patient outcomes, particularly for Medicaid and Medicare patients.

Because the present study suggested poorer outcomes for Medicaid and Medicare patients, and less invasive procedure use for Medicaid patients but more invasive procedure use for Medicare patients, more work needs to be done to explore the variation in invasive procedure use and the indirect effects of structure of care on patient outcomes through their influences on invasive procedure use. In addition, better information needs to be collected in order to understand the relationships between process of care and outcome of care, and between structure of care and outcome of care, and to investigate the poorer outcomes of Medicaid and Medicare patients. For example, health status, access to care, education, and

income of patients may influence patient outcomes and process of care. Other outcome and process of care measures should be considered.

Future work will be needed to understand differences in outcome due to differences in providers. While a number of previous works identified differences in outcomes attributable to differences in patients (Aiken, et. al., 1994; DeBusk, et al., 1983; Franks, et al., 1996; Gillum, et al., 1983; Green, et al., 1990; Gwilt, et al., 1985; Henning, et al., 1979; Leor, et al., 1993; Mark, et al., 1994; McClellan, et al., 1994; Naessens, et al., 1992; OSHPD, 1993; Pozen, et al., 1984; Zehender, et al., 1993), the present study examined several provider characteristics and concluded that these institutional characteristics were associated with patient outcomes. However, it did not include provider differences such as physician specialty or the organization attributes for good nursing care . Earlier studies suggested that differences in mortality outcome are due to these provider differences. For example, Horner et al. (1995) examined the outcomes of stroke patients and in-hospital treatment managed by neurologists versus non-neurologists, and found that patients treated by neurologists experienced lower all-cause and stroke-related mortality. Aiken, et al. (1994) compared mortality outcomes between hospitals known for good nursing care, and hospitals not known for good nursing care, and concluded that the hospitals known for good nursing care had lower Medicare mortality. Therefore, further studies are needed to explore differences in the outcomes for patients treated by different providers.

In addition, data sources for outcome research may also deserve attention. As pointed out earlier, there exists a debate on data sources used for outcome research. While some researchers and quality projects endorse the use of claims (i.e., HEDIS, HCFA Mortality, Naessens, et al., 1992, Udvarhelyi, et al., 1992, and Weiner, et al.,1990), despite the associated disadvantages such as "upcoding" of diagnoses and incomplete data, some researchers question the suitability of claims in outcome research (Jollis et al., 1993). Medical records and patient satisfaction survey data are alternative data sources although they are more expensive and not readily available. However, the suitability of medical records and patient satisfaction survey data seem questionable too. According to a recent study by Greenfield (1997) on a comparison of three data sources (claims, medical records, patient survey) in measuring the number of eye examinations, a quality indicator for patients with diabetes used in HEDIS of NCQA, the number of eye examinations differs depending on the data source used. The study found an 18%, 36%, and 80% eye examination rate respectively for medical records, claims, and patient survey. This implies the poorest results from the medical records yet patients reported much better results. It suggests that outcome results may vary as a result of the data source. The patient survey results are also questionable given the survey participation usually is voluntary, and results are often based on those who respond. More studies are needed to examine these data sources and to understand the appropriate use of data source for outcomes research.

In conclusion, despite the limitations in the present study, the study found structure and process of care associated with outcome of care. Hospital outcome measurement must

take into consideration not only differences in patient risk and severity of illness, but also differences in hospital characteristics and process of care to allow reasonable comparisons across different hospitals. Those hospitals with poorer outcomes should learn from hospitals with better outcomes to improve their patient care. For Medicaid and Medicare programs, they must continue to monitor the quality of care that their beneficiaries receive and revisit their strategies to improve and ensure the quality of care.

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GLOSSARY

AMI

Acute Myocardial Infarction. Condition caused by occlusion of one or more of the coronary arteries. An occulusion is an obstruction or a closure of a passageway or vessel.

CABG

Coronary Artery Bypass Graft Surgery. A method of treating coronary disease by establishing a shunt surgically that permits blood to travel from the aorta to a branch of the artery at a point past an obstruction.

Coronary Angiography

Radiographic examination of the coronary arteries.

FIPA

Freedom Information Practice Act. The information contains hospital discharge data for all acute hospitals in Massachusetts.

ICD-9-CM

International Classification of Disease, Ninth Revision, Clinical Modification.

MCO

Managed Care Organization

NCQA

National Committee for Quality Assurance. A private and non-for-profit organization established to provide managed care health plans with quality credential assessment.

PPE

Plant, property and equipment.

PTCA

Percutaneous Transluminal Coronary Angioplasty. A method of treating localized coronary artery narrowing by using a special double-lumen with a cylindrical balloon to dilate the narrowed vessel.

Logistic Regression

A statsitical method for estimating a model where the dependent variable takes one of two values, for example, die or survive, receive an invasive procedure or not, etc.

Odds, Odds Ratio

The ratio of the probability of an event occurring to it not occurring, in other words, the ratio P/(1-P), where P is the probability of the event occurring.

Significance Level for testing a Null Hypothesis

The probability of incorrectly accepting the null hypothesis when it is in fact true.

Null Hypothesis

A hypothesis, usually one assuming no effect or impact, which can be tested statistically.

P-value

The probability that one would observe an estimate as far or farther away from the null hypothesis than the one which actually was observed, assuming that the null hypothesis is true. If this probability is less than the significance level, the null hypothesis is rejected.

Confidence Level

The probability that a confidence interval for a population parameter includes the true, or actual, value of that parameter.

Confidence Interval

An interval around an estimate of a population parameter, calculated to be wide enough to include the true, unobserved population parameter with a probability equal to the confidence level.

Interaction Effect

The effect that is due to presence of a combination of two or more factors, that is in addition to the separate effects of the factors.

Interactive Variable

A variable that is used to represent an interaction between two or more factors. The variable is operationalized by multiplying the factors together.

APPENDIX A

VARIABLE LIST

Outcome (OUTCOME)

DEATH	A binary variable is code for each patient (1=death, 0=survival).

Patient Demographics (PATDEM):

Age:

CAGE	Years of age.

Age square:

AGESQ	Age*Age.

Age groups:

AGE18_40	Age between 18 and 40.
AGE41_54	Age between 41 and 54.
AGE55_64	Age between 56_64.
AGE65_74	Age between 65 and 74.
AGE75_84	Age between 75 and 84.
AGE85ABV	Age at 85 and older.

Gender:

FEMALE	A binary variable is coded for each female patient (1=female, 0=male).

Race:

NATIVE	Native American people.
ASIAN	Asian people.
BLACK	Black people.
HISPANIC	Hispanic people.
WHITE	White people.

Type of Insurance coverage:

MCDPAY	Medicaid patients.
MCRPAY	Medicare patients excluding patients on the Medicare managed care program.
MCRMGM	Medicare managed care patients.
OGVMTPAY	Patients covered under other government and workers' compensation.
SELFPAY	Self-pay patients.
FREECARE	Free care patients.
COMINDEM	Private-payer patients covered under indemnity plans.
COMMCARE	Private-payer patients covered under commercial managed care plan.

Residential area:

NONBMSA	A binary variable coded for each patient living outside Boston metropolitan service area (MSA) based on patient zip code information and the MSA definition by the U.S. Census Bureau

(1=living outside the Boston MSA, 0=living in the Boston MSA).

Clinical Characteristics (CLINICAL):

Emergency admission:

ADMIERRM	A binary variable is coded for each patient with emergency admission type (1=emergency admission, 0=non-emergency admission).

Transfer:

TRANSFER	A binary variable is coded for each patient with admission source as transfer (1=transfer, 0=non-transfer).

Location of AMI:

ANTERIOR	A binary variable is coded for each patient with diagnosis of anterior wall infarction, anterolateral, inferolateral, other lateral (1=present, 0=none).
INFERIOR	A binary variable is coded for each patient with diagnosis of inferior infarction, posterior, inferoposterior (1=present, 0=none).
SITE_OTH	A binary variable is coded for each patient with diagnosis of infarction other or unspecified (1=present, 0=none).
SUBENDO	A binary variable is coded for each patient with diagnosis of subendocardial infarction (1=present, 0=none).

Other clinical variables:

ATRIBLK	A binary variable is coded for each patient with diagnosis of complete atrioventricular block (1=atrioventricular block, 0=none).
CHF	A binary variable is coded for each patient with diagnosis of congestive heart failure, cardiomyopathy (1=congestive heart failure, 0=none).
CHRLIVER	A binary variable is coded for each patient with diagnosis of chronic liver disease (1=chronic liver disease, 0=none).
CHRRENAL	A binary variable is coded for each patient with diagnosis of chronic renal failure (1=chronic renal failure, 0=none).
DIABETCM	A binary variable is coded for each patient with diagnosis of diabetes, complicated (1=diabetes, 0=none).
DIABETUN	A binary variable is coded for each patient with diagnosis of diabetes, uncomplicated (1=diabetes, 0=none).
HYPER	A binary variable is coded for each patient with diagnosis of hypertension (1=hypertension, 0=none).
HYPO	A binary variable is coded for each patient with diagnosis of hypotension (1=hypotension, 0=none).
LATECVA	A binary variable is coded for each patient with diagnosis of late effects of cerebrovascular disease, hemiplegia (1=present, 0=none).

OTHCEREB	A binary variable is coded for each patient with primary or secondary diagnosis of other major cerebrovascular disease (1=cerebrovascular disease, 0=none).
OTHVALVE	A binary variable is coded for each patient with diagnosis of mitral disorder, rheumatic valve disorders, aortic valve disorders, heart valve replacement. (1=present, 0=none).
PRIMALIG	A binary variable is coded for each patient with diagnosis of primary neoplasm of GI, respiratory, melanoma (1=present, 0=none).
PULEDEMA	A binary variable is coded for each patient with diagnosis of pulmonary edema, adult respiratory distress syndrome (1=present, 0=none).
SEIZURE	A binary variable is coded for each patient with diagnosis of epilepsy, convulsions (1=present, 0=none).
SHOCK	A binary variable is coded for each patient with diagnosis of shock (1=shock, 0=none).
SKNULCER	A binary variable is coded for each patient with diagnosis of chronic skin ulcer (1=present, 0=none).
COMBO4	A binary variable is coded for each patient with diagnosis of both anterior infarction and late effects of cerebrovascular disease, hemiplegia (1=present, 0=none).
PRCBAG	A binary variable is coded for each patient with diagnosis of prior CABG (1=present, 0=none).

Hospital Skill Variables (SKILLS):

AMI patient volume in thousand:

HOSPAMIV	Hospital volume of AMI patients per year.

Hospital Structural Variables (HOSPSTRU):

Investment in billion:

GROPPE95	Gloss value in plant, property and equipment (PPE).

Hospital size and staff resource:

NURSEBED	Number of registered nurses per operating bed.

Tertiary:

TERTIARY	A binary variable is coded for each patient admitted in a tertiary hospital (1=tertiary, 0=none).

Process of Care Variables (PROCESS):

Any invasive procedure use:

INVASIVE	A binary variable is coded for each patient who received an invasive procedure (1=an invasive procedure, 0=non-invasive procedure).

Types of invasive procedure use:

JLANGIO	Coronary angiography.
JLPCTA	Percutaneous translumina coronary angioplasty (PTCA).
JLCABG	Coronary artery bypass graft surgery.
JLPTCB	PTCA and CABG.
NOINPROC	Non-invasive procedures.

APPENDIX B

ICD-9-CM CODE LIST

Clinical Characteristics (CLINICAL)	**Primary and Secondary Diagnosis (ICD-9-CM)**
Location of AMI:	
ANTERIOR	410-410.09; 410.10-410.19; 410.20-410.29; 410.50-410.59.
INFERIOR	410.30-410.39; 410.40-410.49; 410.60-410.69.
SITE_OTH	410.80-410.89; 410.90-410.99.
SUBENDO	410.70-410.79.
Other clinical variables:	
ATRIBLK	426.0.
CHF	425.0-425.9; 428.0-428.9.
CHRLIVER	456.0-456.29; 571.00-571.99; 572.2-572.8; 573.0.
CHRRENAL	585; 403.01-403.91; 404.02-404.92; 404.03-404.93; V451.
DIABETCM	250.10-250.99; 357.2; 362.00-362.09.
DIABETUN	250.00-250.09.
HYPER	401.0-401.9; 402.00-402.90; 403.00-403.90; 404.00-404.90; 405.00-405.99.
HYPO	458.9.
LATECVA	438; 342.0-342.9.
OTHCEREB	430-434.9; 436; 437.0-437.1; 437.8-437.9.
OTHVALVE	394.0-397.9; 424.1-424.99; V422; V433; 966.02; 352.0-352.9.
PRIMALIG	141.0-172.9.
PULEDEMA	514; 518.4-518.5; 518.81-518.82.
SEIZURE	345.00-345.99; 780.3.
SHOCK	785.5-785.59.
SKNULCER	707.0-707.9.
PRCBAG	996.03.

Process of Care Variables (PROCESS)	**Primary and Secondary Procedure (ICD-9-CM)**
Any invasive procedure use	
INVASIVE	360-360.2; 360.5; 360-360.2; 361.0-361.9; 372.2; 372.3; 885.5-885.7.
Types of invasive procedure use:	
JLANGIO	372.2; 372.3; 885.5-885.7.
JLPCTA	360-360.2; 360.5; 360-360.2.
JLCABG	361.0-361.9.

APPENDIX C

INITIAL OUTCOME MODEL

The LOGISTIC Procedure

Data Set: WORK.FINAL1
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7932.022	.
SC	9904.394	8279.310	.
-2 LOG L	9894.844	7840.022	2054.823 with 45 DF (p=0.0001)
Score	.	.	2202.838 with 45 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.7036	1.0439	69.5194	0.0001	.	.
CAGE	1	0.0794	0.0296	7.1922	0.0073	0.591460	1.083
AGESQ	1	-0.00016	0.000222	0.5066	0.4766	-0.157143	1.000
FEMALE	1	0.0820	0.0619	1.7581	0.1849	0.022426	1.086
NATIVE	1	1.0819	0.5297	4.1716	0.0411	0.030990	2.950
ASIAN	1	-0.2947	0.5750	0.2627	0.6083	-0.009082	0.745
BLACK	1	-0.1390	0.2215	0.3939	0.5303	-0.011366	0.870
HISPANIC	1	-0.5417	0.3262	2.7582	0.0968	-0.037342	0.582
MCDPAY	1	0.5532	0.2535	4.7637	0.0291	0.047555	1.739
MCRPAY	1	1.9168	0.6407	8.9492	0.0028	0.510862	6.799
AMCRPAY	1	-0.0229	0.00904	6.4356	0.0112	-0.475540	0.977
MCRMGM	1	0.00839	0.2442	0.0012	0.9726	0.000759	1.008
OGVMTPAY	1	0.1822	0.4662	0.1528	0.6959	0.009093	1.200
SELFPAY	1	0.3226	0.2831	1.2985	0.2545	0.027695	1.381
FREECARE	1	-0.9204	0.7445	1.5282	0.2164	-0.051996	0.398
COMMCARE	1	0.1968	0.1701	1.3376	0.2475	0.039690	1.217

NONBMSA	1	-0.0588	0.0751	0.6132	0.4336	-0.013209	0.943
ADMIERRM	1	0.2011	0.0901	4.9773	0.0257	0.053523	1.223
TRANSFER	1	0.5237	0.1326	15.6045	0.0001	0.121996	1.688
ANTERIOR	1	1.0383	0.1602	41.9908	0.0001	0.253425	2.824
ATRIBLK	1	0.7898	0.1440	30.0947	0.0001	0.065382	2.203
CHF	1	0.2684	0.0644	17.3993	0.0001	0.072179	1.308
CHRLIVER	1	0.7199	0.2859	6.3411	0.0118	0.031500	2.054
CHRRENAL	1	0.2502	0.1133	4.8764	0.0272	0.031370	1.284
DIABETCM	1	0.3916	0.1273	9.4624	0.0021	0.047114	1.479
DIABETUN	1	-0.0930	0.0916	1.0304	0.3101	-0.017542	0.911
HYPER	1	-0.5224	0.0696	56.3247	0.0001	-0.138895	0.593
HYPO	1	0.8438	0.0871	93.7571	0.0001	0.126967	2.325
INFERIOR	1	0.6718	0.1633	16.9280	0.0001	0.160145	1.958
OTHCEREB	1	-0.0915	0.0633	2.0860	0.1487	-0.023955	0.913
LATECVA	1	0.5919	0.2330	6.4554	0.0111	0.065426	1.807
OTHVALVE	1	-0.6500	0.1277	25.9022	0.0001	-0.090092	0.522
PRIMALIG	1	0.6048	0.2359	6.5750	0.0103	0.030695	1.831
PULEDEMA	1	1.6586	0.1004	272.7473	0.0001	0.185391	5.252
SEIZURE	1	0.6510	0.1576	17.0648	0.0001	0.051985	1.917
SHOCK	1	1.5799	0.3654	18.6972	0.0001	0.048130	4.854
SITE_OTH	1	1.6116	0.1681	91.9507	0.0001	0.239751	5.011
SKNULCER	1	0.2877	0.2351	1.4973	0.2211	0.015590	1.333
SUBENDO	1	-0.1530	0.1598	0.9178	0.3381	-0.041695	0.858
COMBO4	1	-0.0566	0.1809	0.0978	0.7545	-0.006167	0.945
PRCABG	1	0.9829	0.5168	3.6174	0.0572	0.027782	2.672
HOSPAMIV	1	0.3185	0.1601	3.9563	0.0467	0.057213	1.375
GROPPE95	1	-0.0553	0.2562	0.0466	0.8291	-0.006788	0.946
NURSEBED	1	-0.0617	0.1264	0.2386	0.6252	-0.011706	0.940
TERTIARY	1	0.3036	0.1292	5.5160	0.0188	0.080527	1.355
INVASIVE	1	-1.1458	0.1033	123.0110	0.0001	-0.306113	0.318

Association of Predicted Probabilities and Observed Responses

Concordant	= 81.9%	Somers' D	= 0.642
Discordant	= 17.7%	Gamma	= 0.645
Tied	= 0.4%	Tau-a	= 0.129
(19731888 pairs)		c	= 0.821

FULL OUTCOME MODEL

The LOGISTIC Procedure

Data Set: WORK.FINAL1
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7925.670	.
SC	9904.394	8227.660	.
-2 LOG L	9894.844	7845.670	2049.174 with 39 DF (p=0.0001)
Score	.	.	2188.308 with 39 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.0941	0.5212	241.1993	0.0001	.	.
CAGE	1	0.0585	0.00643	82.6062	0.0001	0.435715	1.060
FEMALE	1	0.0879	0.0616	2.0379	0.1534	0.024022	1.092
NATIVE	1	1.0505	0.5276	3.9646	0.0465	0.030090	2.859
ASIAN	1	-0.2989	0.5776	0.2678	0.6048	-0.009211	0.742
BLACK	1	-0.1398	0.2215	0.3985	0.5279	-0.011434	0.870
HISPANIC	1	-0.5467	0.3262	2.8093	0.0937	-0.037685	0.579
MCDPAY	1	0.5436	0.2534	4.6008	0.0320	0.046727	1.722
MCRPAY	1	2.1280	0.5211	16.6734	0.0001	0.567138	8.398
AMCRPAY	1	-0.0258	0.00744	12.0517	0.0005	-0.535940	0.974
MCRMGM	1	-0.00186	0.2430	0.0001	0.9939	-0.000169	0.998
OGVMTPAY	1	0.1880	0.4657	0.1630	0.6864	0.009383	1.207
SELFPAY	1	0.3125	0.2821	1.2271	0.2680	0.026828	1.367
FREECARE	1	-0.9120	0.7441	1.5022	0.2203	-0.051523	0.402
COMMCARE	1	0.2008	0.1699	1.3969	0.2372	0.040496	1.222

ADMIERRM	1	0.1961	0.0899	4.7563	0.0292	0.052194	1.217
TRANSFER	1	0.5236	0.1324	15.6504	0.0001	0.121979	1.688
ANTERIOR	1	1.0452	0.1598	42.7617	0.0001	0.255114	2.844
ATRIBLK	1	0.7913	0.1440	30.1948	0.0001	0.065504	2.206
CHF	1	0.2719	0.0628	18.7451	0.0001	0.073104	1.312
CHRLIVER	1	0.7084	0.2860	6.1367	0.0132	0.030997	2.031
CHRRENAL	1	0.2324	0.1123	4.2848	0.0385	0.029133	1.262
DIABETCM	1	0.4216	0.1258	11.2214	0.0008	0.050723	1.524
HYPER	1	-0.5217	0.0684	58.2077	0.0001	-0.138705	0.594
HYPO	1	0.8582	0.0863	98.8664	0.0001	0.129129	2.359
INFERIOR	1	0.6840	0.1625	17.7215	0.0001	0.163049	1.982
LATECVA	1	0.5721	0.2311	6.1275	0.0133	0.063229	1.772
OTHVALVE	1	-0.6492	0.1276	25.8684	0.0001	-0.089992	0.522
PRIMALIG	1	0.6138	0.2354	6.8008	0.0091	0.031152	1.847
PULEDEMA	1	1.6569	0.1000	274.7790	0.0001	0.185208	5.243
SEIZURE	1	0.6564	0.1572	17.4339	0.0001	0.052418	1.928
SHOCK	1	1.6193	0.3651	19.6733	0.0001	0.049332	5.050
SITE_OTH	1	1.6165	0.1676	93.0473	0.0001	0.240485	5.036
SUBENDO	1	-0.1433	0.1592	0.8104	0.3680	-0.039033	0.867
PRCABG	1	0.9711	0.5157	3.5458	0.0597	0.027449	2.641
HOSPAMIV	1	0.3169	0.1598	3.9326	0.0474	0.056936	1.373
GROPPE95	1	-0.0255	0.2530	0.0102	0.9197	-0.003132	0.975
NURSEBED	1	-0.0517	0.1255	0.1700	0.6801	-0.009811	0.950
TERTIARY	1	0.2833	0.1269	4.9863	0.0255	0.075161	1.328
INVASIVE	1	-1.1380	0.1030	122.1585	0.0001	-0.304050	0.320

Association of Predicted Probabilities and Observed Responses

Concordant	= 81.9%	Somers' D	= 0.642
Discordant	= 17.7%	Gamma	= 0.644
Tied	= 0.4%	Tau-a	= 0.128
(19731888 pairs)		c	= 0.821

APPENDIX D

FINAL OUTCOME MODEL (1)

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7922.456	.
SC	9904.394	8201.796	.
-2 LOG L	9894.844	7848.456	2046.388 with 36 DF (p=0.0001)
Score	.	.	2185.740 with 36 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.1501	0.5196	246.0353	0.0001	.	.
CAGE	1	0.0611	0.00666	84.2344	0.0001	0.455407	1.063
FEMALE	1	0.0901	0.0615	2.1435	0.1432	0.024623	1.094
NATIVE	1	1.0765	0.5264	4.1816	0.0409	0.030835	2.934
ASIAN	1	-0.3875	0.5798	0.4467	0.5039	-0.011942	0.679
BLACK	1	-0.1447	0.2212	0.4278	0.5131	-0.011831	0.865
HISPANIC	1	-0.5340	0.3260	2.6837	0.1014	-0.036810	0.586
MCDPAY	1	0.4285	0.2326	3.3941	0.0654	0.036832	1.535
MCRPAY	1	2.1959	0.5176	17.9985	0.0001	0.575336	8.988
AMCRPAY	1	-0.0288	0.00762	14.2979	0.0002	-0.587582	0.972
OGVMTPAY	1	0.0705	0.4547	0.0240	0.8768	0.003519	1.073
UNINSUD	1	-0.00725	0.2492	0.0008	0.9768	-0.000739	0.993
ADMIERRM	1	0.1946	0.0899	4.6829	0.0305	0.051789	1.215
TRANSFER	1	0.5201	0.1323	15.4577	0.0001	0.121164	1.682
ANTERIOR	1	1.0515	0.1600	43.1962	0.0001	0.256653	2.862

ATRIBLK	1	0.7920	0.1439	30.2963	0.0001	0.065564	2.208
CHF	1	0.2731	0.0628	18.9275	0.0001	0.073435	1.314
CHRLIVER	1	0.7072	0.2859	6.1169	0.0134	0.030944	2.028
CHRRENAL	1	0.2331	0.1122	4.3154	0.0378	0.029227	1.263
DIABETCM	1	0.4175	0.1258	11.0129	0.0009	0.050232	1.518
HYPER	1	-0.5241	0.0684	58.7850	0.0001	-0.139354	0.592
HYPO	1	0.8574	0.0863	98.7217	0.0001	0.129008	2.357
INFERIOR	1	0.6910	0.1626	18.0519	0.0001	0.164715	1.996
LATECVA	1	0.5777	0.2308	6.2654	0.0123	0.063851	1.782
OTHVALVE	1	-0.6470	0.1277	25.6742	0.0001	-0.089680	0.524
PRIMALIG	1	0.6103	0.2355	6.7128	0.0096	0.030973	1.841
PULEDEMA	1	1.6585	0.1000	275.1075	0.0001	0.185384	5.251
SEIZURE	1	0.6589	0.1571	17.5893	0.0001	0.052615	1.933
SHOCK	1	1.6213	0.3647	19.7594	0.0001	0.049391	5.059
SITE_OTH	1	1.6234	0.1676	93.7756	0.0001	0.241503	5.070
SUBENDO	1	-0.1357	0.1593	0.7258	0.3942	-0.036966	0.873
PRCABG	1	0.9736	0.5161	3.5594	0.0592	0.027521	2.648
HOSPAMIV	1	0.3191	0.1578	4.0877	0.0432	0.057331	1.376
GROPPE95	1	-0.0329	0.2531	0.0169	0.8967	-0.004033	0.968
NURSEBED	1	-0.0556	0.1256	0.1962	0.6578	-0.010545	0.946
TERTIARY	1	0.2896	0.1254	5.3367	0.0209	0.076832	1.336
INVASIVE	1	-1.1406	0.1028	123.0564	0.0001	-0.304740	0.320

Association of Predicted Probabilities and Observed Responses

Concordant	= 81.9%	Somers' D	= 0.642
Discordant	= 17.7%	Gamma	= 0.644
Tied	= 0.4%	Tau-a	= 0.128
(19731888 pairs)		c	= 0.821

APPENDIX E

FINAL OUTCOME MODEL (1) WITH PATIENTS OF INDEMNITY PLANS AS BASE GROUP

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7922.989	.
SC	9904.394	8209.879	.
-2 LOG L	9894.844	7846.989	2047.855 with 37 DF (p=0.0001)
Score	.	.	2186.428 with 37 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.2906	0.5335	241.4948	0.0001	.	.
CAGE	1	0.0615	0.00667	84.9534	0.0001	0.458069	1.063
FEMALE	1	0.0901	0.0615	2.1423	0.1433	0.024617	1.094
NATIVE	1	1.0599	0.5288	4.0183	0.0450	0.030360	2.886
ASIAN	1	-0.3902	0.5799	0.4528	0.5010	-0.012024	0.677
BLACK	1	-0.1505	0.2213	0.4624	0.4965	-0.012305	0.860
HISPANIC	1	-0.5386	0.3259	2.7304	0.0985	-0.037125	0.584
MCDPAY	1	0.5481	0.2542	4.6507	0.0310	0.047112	1.730
MCRPAY	1	2.3367	0.5318	19.3040	0.0001	0.612211	10.347
AMCRPAY	1	-0.0292	0.00763	14.6153	0.0001	-0.594762	0.971
OGVMTPAY	1	0.1900	0.4661	0.1662	0.6835	0.009484	1.209
UNINSUD	1	0.1122	0.2694	0.1735	0.6770	0.011446	1.119
COMMCARE	1	0.2052	0.1703	1.4530	0.2280	0.041395	1.228

ADMIERRM	1	0.1942	0.0899	4.6652	0.0308	0.051682	1.214
TRANSFER	1	0.5193	0.1322	15.4260	0.0001	0.120973	1.681
ANTERIOR	1	1.0513	0.1599	43.2213	0.0001	0.256602	2.861
ATRIBLK	1	0.7913	0.1439	30.2318	0.0001	0.065501	2.206
CHF	1	0.2728	0.0628	18.8919	0.0001	0.073370	1.314
CHRLIVER	1	0.7096	0.2860	6.1558	0.0131	0.031048	2.033
CHRRENAL	1	0.2341	0.1122	4.3506	0.0370	0.029350	1.264
DIABETCM	1	0.4182	0.1258	11.0587	0.0009	0.050322	1.519
HYPER	1	-0.5243	0.0684	58.8364	0.0001	-0.139415	0.592
HYPO	1	0.8574	0.0863	98.7171	0.0001	0.129007	2.357
INFERIOR	1	0.6910	0.1625	18.0734	0.0001	0.164722	1.996
LATECVA	1	0.5798	0.2308	6.3078	0.0120	0.064080	1.786
OTHVALVE	1	-0.6468	0.1277	25.6628	0.0001	-0.089655	0.524
PRIMALIG	1	0.6049	0.2357	6.5869	0.0103	0.030699	1.831
PULEDEMA	1	1.6583	0.1000	274.9239	0.0001	0.185360	5.250
SEIZURE	1	0.6620	0.1571	17.7488	0.0001	0.052868	1.939
SHOCK	1	1.6262	0.3652	19.8264	0.0001	0.049542	5.085
SITE_OTH	1	1.6252	0.1676	94.0468	0.0001	0.241774	5.079
SUBENDO	1	-0.1359	0.1592	0.7292	0.3931	-0.037035	0.873
PRCABG	1	0.9693	0.5159	3.5297	0.0603	0.027396	2.636
HOSPAMIV	1	0.3216	0.1578	4.1541	0.0415	0.057788	1.379
GROPPE95	1	-0.0288	0.2531	0.0129	0.9094	-0.003535	0.972
NURSEBED	1	-0.0591	0.1256	0.2212	0.6381	-0.011199	0.943
TERTIARY	1	0.2886	0.1254	5.2969	0.0214	0.076552	1.335
INVASIVE	1	-1.1389	0.1028	122.7468	0.0001	-0.304269	0.320

Association of Predicted Probabilities and Observed Responses

Concordant	= 81.9%	Somers' D	= 0.642
Discordant	= 17.7%	Gamma	= 0.644
Tied	= 0.4%	Tau-a	= 0.128
(19731888 pairs)		c	= 0.821

FINAL OUTCOME MODEL (1) WITH PATIENTS OF MANAGED CARE AS BASE GROUP

The LOGISTIC Procedure

Oata Set: WORK.F
Response Variable: OEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	OEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7922.989	.
SC	9904.394	8209.879	.
-2 LOG L	9894.844	7846.989	2047.855 with 37 OF (p=0.0001)
Score	.	.	2186.428 with 37 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.0854	0.5217	240.2320	0.0001	.	.
CAGE	1	0.0615	0.00667	84.9534	0.0001	0.458069	1.063
FEMALE	1	0.0901	0.0615	2.1423	0.1433	0.024617	1.094
NATIVE	1	1.0599	0.5288	4.0183	0.0450	0.030360	2.886
ASIAN	1	-0.3902	0.5799	0.4528	0.5010	-0.012024	0.677
BLACK	1	-0.1505	0.2213	0.4624	0.4965	-0.012305	0.860
HISPANIC	1	-0.5386	0.3259	2.7304	0.0985	-0.037125	0.584
MCOPAY	1	0.3429	0.2423	2.0015	0.1571	0.029471	1.409
MCRPAY	1	2.1314	0.5200	16.8034	0.0001	0.558441	8.427
AMCRPAY	1	-0.0292	0.00763	14.6153	0.0001	-0.594762	0.971
OGVMTPAY	1	-0.0152	0.4598	0.0011	0.9736	-0.000758	0.985
UNINSUO	1	-0.0930	0.2584	0.1295	0.7189	-0.009482	0.911
COMINDEM	1	-0.2052	0.1703	1.4530	0.2280	-0.036323	0.814

ADMIERRM	1	0.1942	0.0899	4.6652	0.0308	0.051682	1.214
TRANSFER	1	0.5193	0.1322	15.4260	0.0001	0.120973	1.681
ANTERIOR	1	1.0513	0.1599	43.2213	0.0001	0.256602	2.861
ATRIBLK	1	0.7913	0.1439	30.2318	0.0001	0.065501	2.206
CHF	1	0.2728	0.0628	18.8919	0.0001	0.073370	1.314
CHRLIVER	1	0.7096	0.2860	6.1558	0.0131	0.031048	2.033
CHRRENAL	1	0.2341	0.1122	4.3506	0.0370	0.029350	1.264
DIABETCM	1	0.4182	0.1258	11.0587	0.0009	0.050322	1.519
HYPER	1	-0.5243	0.0684	58.8364	0.0001	-0.139415	0.592
HYPO	1	0.8574	0.0863	98.7171	0.0001	0.129007	2.357
INFERIOR	1	0.6910	0.1625	18.0734	0.0001	0.164722	1.996
LATECVA	1	0.5798	0.2308	6.3078	0.0120	0.064080	1.786
OTHVALVE	1	-0.6468	0.1277	25.6628	0.0001	-0.089655	0.524
PRIMALIG	1	0.6049	0.2357	6.5869	0.0103	0.030699	1.831
PULEDEMA	1	1.6583	0.1000	274.9239	0.0001	0.185360	5.250
SEIZURE	1	0.6620	0.1571	17.7488	0.0001	0.052868	1.939
SHOCK	1	1.6262	0.3652	19.8264	0.0001	0.049542	5.085
SITE_OTH	1	1.6252	0.1676	94.0468	0.0001	0.241774	5.079
SUBENDO	1	-0.1359	0.1592	0.7292	0.3931	-0.037035	0.873
PRCABG	1	0.9693	0.5159	3.5297	0.0603	0.027396	2.636
HOSPAMIV	1	0.3216	0.1578	4.1541	0.0415	0.057788	1.379
GROPPE95	1	-0.0288	0.2531	0.0129	0.9094	-0.003535	0.972
NURSEBED	1	-0.0591	0.1256	0.2212	0.6381	-0.011199	0.943
TERTIARY	1	0.2886	0.1254	5.2969	0.0214	0.076552	1.335
INVASIVE	1	-1.1389	0.1028	122.7468	0.0001	-0.304269	0.320

Association of Predicted Probabilities and Observed Responses

Concordant = 81.9%	Somers' D = 0.642
Discordant = 17.7%	Gamma = 0.644
Tied = 0.4%	Tau-a = 0.128
(19731888 pairs)	c = 0.821

APPENDIX F

FINAL OUTCOME MODEL (2)

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7917.539	.
SC	9904.394	8219.528	.
-2 LOG L	9894.844	7837.539	2057.306 with 39 DF (p=0.0001)
Score	.	.	2192.953 with 39 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.1652	0.5207	245.9075	0.0001	.	.
CAGE	1	0.0608	0.00668	82.8588	0.0001	0.453316	1.063
FEMALE	1	0.0896	0.0616	2.1145	0.1459	0.024488	1.094
NATIVE	1	1.1301	0.5343	4.4729	0.0344	0.032370	3.096
ASIAN	1	-0.3814	0.5807	0.4314	0.5113	-0.011753	0.683
BLACK	1	-0.1585	0.2214	0.5128	0.4739	-0.012963	0.853
HISPANIC	1	-0.5423	0.3262	2.7639	0.0964	-0.037383	0.581
MCDPAY	1	0.4253	0.2328	3.3384	0.0677	0.036559	1.530
MCRPAY	1	2.1677	0.5193	17.4276	0.0001	0.567938	8.738
AMCRPAY	1	-0.0284	0.00764	13.8419	0.0002	-0.579877	0.972
OGVMTPAY	1	0.0431	0.4559	0.0090	0.9246	0.002153	1.044
UNINSUD	1	-0.00049	0.2492	0.0000	0.9984	-0.000049869	1.000
ADMIERRM	1	0.1929	0.0899	4.6020	0.0319	0.051348	1.213
TRANSFER	1	0.5491	0.1328	17.0903	0.0001	0.127925	1.732
ANTERIOR	1	1.0552	0.1601	43.4369	0.0001	0.257544	2.872
ATRIBLK	1	0.7994	0.1440	30.7963	0.0001	0.066174	2.224

CHF	1	0.2643	0.0628	17.6986	0.0001	0.071063	1.302
CHRLIVER	1	0.6870	0.2859	5.7747	0.0163	0.030059	1.988
CHRRENAL	1	0.2304	0.1122	4.2154	0.0401	0.028886	1.259
DIABETCM	1	0.4070	0.1260	10.4422	0.0012	0.048974	1.502
HYPER	1	-0.5216	0.0684	58.0821	0.0001	-0.138679	0.594
HYPO	1	0.8512	0.0863	97.1885	0.0001	0.128083	2.343
INFERIOR	1	0.6973	0.1627	18.3639	0.0001	0.166208	2.008
LATECVA	1	0.5901	0.2308	6.5355	0.0106	0.065220	1.804
OTHVALVE	1	-0.6520	0.1276	26.1036	0.0001	-0.090372	0.521
PRIMALIG	1	0.6094	0.2356	6.6892	0.0097	0.030931	1.839
PULEDEMA	1	1.6525	0.1002	272.0082	0.0001	0.184716	5.220
SEIZURE	1	0.6541	0.1574	17.2819	0.0001	0.052236	1.923
SHOCK	1	1.6131	0.3645	19.5819	0.0001	0.049143	5.018
SITE_OTH	1	1.6248	0.1678	93.7307	0.0001	0.241723	5.078
SUBENDO	1	-0.1413	0.1595	0.7850	0.3756	-0.038507	0.868
PRCABG	1	0.9026	0.5188	3.0265	0.0819	0.025512	2.466
HOSPAMIV	1	0.3288	0.1581	4.3286	0.0375	0.059079	1.389
GROPPE95	1	-0.0455	0.2538	0.0321	0.8578	-0.005584	0.956
NURSEBED	1	-0.0337	0.1258	0.0718	0.7887	-0.006392	0.967
TERTIARY	1	0.2987	0.1257	5.6480	0.0175	0.079251	1.348
JLANGIO	1	-0.9060	0.1255	52.1251	0.0001	-0.169149	0.404
JLPTCA	1	-1.4473	0.1475	96.2551	0.0001	-0.291131	0.235
JLCABG	1	-1.1829	0.1644	51.7603	0.0001	-0.176706	0.306
JLPTCB	1	-1.0561	0.4401	5.7591	0.0164	-0.047732	0.348

Association of Predicted Probabilities and Observed Responses

Concordant = 82.0%	Somers' D = 0.644
Discordant = 17.6%	Gamma = 0.646
Tied = 0.4%	Tau-a = 0.129
(19731888 pairs)	c = 0.822

APPENDIX G

FINAL OUTCOME MODEL (2) WITH PATIENTS OF INDEMNITY PLANS AS BASE GROUP

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7917.927	.
SC	9904.394	8227.467	.
-2 LOG L	9894.844	7835.927	2058.917 with 40 DF (p=0.0001)
Score	.	.	2193.666 with 40 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.3133	0.5348	241.6550	0.0001	.	.
CAGE	1	0.0612	0.00669	83.6202	0.0001	0.456148	1.063
FEMALE	1	0.0896	0.0616	2.1135	0.1460	0.024483	1.094
NATIVE	1	1.1122	0.5371	4.2887	0.0384	0.031857	3.041
ASIAN	1	-0.3843	0.5807	0.4380	0.5081	-0.011843	0.681
BLACK	1	-0.1647	0.2215	0.5529	0.4571	-0.013466	0.848
HISPANIC	1	-0.5474	0.3262	2.8159	0.0933	-0.037731	0.578
MCDPAY	1	0.5508	0.2544	4.6862	0.0304	0.047346	1.735
MCRPAY	1	2.3154	0.5335	18.8329	0.0001	0.606638	10.129
AMCRPAY	1	-0.0288	0.00765	14.1716	0.0002	-0.587454	0.972
OGVMTPAY	1	0.1683	0.4672	0.1297	0.7188	0.008397	1.183
UNINSUD	1	0.1250	0.2696	0.2149	0.6429	0.012747	1.133
COMMCARE	1	0.2154	0.1706	1.5952	0.2066	0.043451	1.240

ADMIERRM	1	0.1925	0.0899	4.5838	0.0323	0.051239	1.212
TRANSFER	1	0.5481	0.1328	17.0465	0.0001	0.127686	1.730
ANTERIOR	1	1.0551	0.1600	43.4694	0.0001	0.257517	2.872
ATRIBLK	1	0.7986	0.1441	30.7244	0.0001	0.066107	2.222
CHF	1	0.2640	0.0628	17.6603	0.0001	0.070989	1.302
CHRLIVER	1	0.6892	0.2859	5.8119	0.0159	0.030156	1.992
CHRRENAL	1	0.2315	0.1122	4.2534	0.0392	0.029020	1.260
DIABETCM	1	0.4077	0.1259	10.4822	0.0012	0.049052	1.503
HYPER	1	-0.5219	0.0684	58.1573	0.0001	-0.138767	0.593
HYPO	1	0.8512	0.0863	97.1792	0.0001	0.128082	2.343
INFERIOR	1	0.6974	0.1626	18.3908	0.0001	0.166235	2.008
LATECVA	1	0.5923	0.2309	6.5827	0.0103	0.065471	1.808
OTHVALVE	1	-0.6519	0.1276	26.0998	0.0001	-0.090359	0.521
PRIMALIG	1	0.6040	0.2358	6.5632	0.0104	0.030657	1.830
PULEDEMA	1	1.6524	0.1002	271.8791	0.0001	0.184697	5.219
SEIZURE	1	0.6573	0.1574	17.4413	0.0001	0.052492	1.930
SHOCK	1	1.6180	0.3651	19.6436	0.0001	0.049291	5.043
SITE_OTH	1	1.6269	0.1678	94.0155	0.0001	0.242022	5.088
SUBENDO	1	-0.1416	0.1595	0.7889	0.3744	-0.038585	0.868
PRCABG	1	0.8984	0.5187	3.0001	0.0833	0.025393	2.456
HOSPAMIV	1	0.3316	0.1580	4.4031	0.0359	0.059578	1.393
GROPPE95	1	-0.0411	0.2539	0.0262	0.8713	-0.005048	0.960
NURSEBED	1	-0.0372	0.1258	0.0876	0.7673	-0.007058	0.963
TERTIARY	1	0.2977	0.1257	5.6089	0.0179	0.078985	1.347
JLANGIO	1	-0.9030	0.1255	51.8016	0.0001	-0.168587	0.405
JLPTCA	1	-1.4477	0.1475	96.3515	0.0001	-0.291206	0.235
JLCABG	1	-1.1803	0.1644	51.5463	0.0001	-0.176315	0.307
JLPTCB	1	-1.0460	0.4404	5.6428	0.0175	-0.047279	0.351

Association of Predicted Probabilities and Observed Responses

Concordant	= 82.0%	Somers' D	= 0.644
Discordant	= 17.6%	Gamma	= 0.646
Tied	= 0.4%	Tau-a	= 0.129
(19731888 pairs)		c	= 0.822

FINAL OUTCOME MODEL (2) WITH PATIENTS OF MANAGED CARE AS BASE GROUP

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: DEATH   Adverse Outcome
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	DEATH	Count
1	1	1584
2	0	12457

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	9896.844	7917.927	.
SC	9904.394	8227.467	.
-2 LOG L	9894.844	7835.927	2058.917 with 40 DF (p=0.0001)
Score	.	.	2193.666 with 40 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.0979	0.5227	240.0151	0.0001	.	.
CAGE	1	0.0612	0.00669	83.6202	0.0001	0.456148	1.063
FEMALE	1	0.0896	0.0616	2.1135	0.1460	0.024483	1.094
NATIVE	1	1.1122	0.5371	4.2887	0.0384	0.031857	3.041
ASIAN	1	-0.3843	0.5807	0.4380	0.5081	-0.011843	0.681
BLACK	1	-0.1647	0.2215	0.5529	0.4571	-0.013466	0.848
HISPANIC	1	-0.5474	0.3262	2.8159	0.0933	-0.037731	0.578
MCDPAY	1	0.3354	0.2425	1.9124	0.1667	0.028830	1.398
MCRPAY	1	2.1000	0.5216	16.2085	0.0001	0.550198	8.166
AMCRPAY	1	-0.0288	0.00765	14.1716	0.0002	-0.587454	0.972
OGVMTPAY	1	-0.0472	0.4610	0.0105	0.9185	-0.002353	0.954
UNINSUD	1	-0.0904	0.2584	0.1224	0.7264	-0.009221	0.914

COMINDEM	1	-0.2154	0.1706	1.5952	0.2066	-0.038127	0.806
ADMIERRM	1	0.1925	0.0899	4.5838	0.0323	0.051239	1.212
TRANSFER	1	0.5481	0.1328	17.0465	0.0001	0.127686	1.730
ANTERIOR	1	1.0551	0.1600	43.4694	0.0001	0.257517	2.872
ATRIBLK	1	0.7986	0.1441	30.7244	0.0001	0.066107	2.222
CHF	1	0.2640	0.0628	17.6603	0.0001	0.070989	1.302
CHRLIVER	1	0.6892	0.2859	5.8119	0.0159	0.030156	1.992
CHRRENAL	1	0.2315	0.1122	4.2534	0.0392	0.029020	1.260
DIABETCM	1	0.4077	0.1259	10.4822	0.0012	0.049052	1.503
HYPER	1	-0.5219	0.0684	58.1573	0.0001	-0.138767	0.593
HYPO	1	0.8512	0.0863	97.1792	0.0001	0.128082	2.343
INFERIOR	1	0.6974	0.1626	18.3908	0.0001	0.166235	2.008
LATECVA	1	0.5923	0.2309	6.5827	0.0103	0.065471	1.808
OTHVALVE	1	-0.6519	0.1276	26.0998	0.0001	-0.090359	0.521
PRIMALIG	1	0.6040	0.2358	6.5632	0.0104	0.030657	1.830
PULEDEMA	1	1.6524	0.1002	271.8791	0.0001	0.184697	5.219
SEIZURE	1	0.6573	0.1574	17.4413	0.0001	0.052492	1.930
SHOCK	1	1.6180	0.3651	19.6436	0.0001	0.049291	5.043
SITE_OTH	1	1.6269	0.1678	94.0155	0.0001	0.242022	5.088
SUBENDO	1	-0.1416	0.1595	0.7889	0.3744	-0.038585	0.868
PRCABG	1	0.8984	0.5187	3.0001	0.0833	0.025393	2.456
HOSPAMIV	1	0.3316	0.1580	4.4031	0.0359	0.059578	1.393
GROPPE95	1	-0.0411	0.2539	0.0262	0.8713	-0.005048	0.960
NURSEBED	1	-0.0372	0.1258	0.0876	0.7673	-0.007058	0.963
TERTIARY	1	0.2977	0.1257	5.6089	0.0179	0.078985	1.347
JLANGIO	1	-0.9030	0.1255	51.8016	0.0001	-0.168587	0.405
JLPTCA	1	-1.4477	0.1475	96.3515	0.0001	-0.291206	0.235
JLCABG	1	-1.1803	0.1644	51.5463	0.0001	-0.176315	0.307
JLPTCB	1	-1.0460	0.4404	5.6428	0.0175	-0.047279	0.351

Association of Predicted Probabilities and Observed Responses

Concordant = 82.0%	Somers' D = 0.644
Discordant = 17.6%	Gamma = 0.646
Tied = 0.4%	Tau-a = 0.129
(19731888 pairs)	c = 0.822

APPENDIX H

INITIAL PROCESS MODEL

The LOGISTIC Procedure

Data Set: WORK.FINAL1
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10835.000	.
SC	18612.543	11167.189	.
-2 LOG L	18602.993	10747.000	7855.993 with 43 DF (p=0.0001)
Score	.	.	6535.538 with 43 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.7563	0.7025	155.3806	0.0001	.	.
CAGE	1	0.2394	0.0218	120.8201	0.0001	1.783895	1.270
AGESQ	1	-0.00240	0.000186	166.2935	0.0001	-2.391462	0.998
FEMALE	1	-0.0921	0.0519	3.1450	0.0762	-0.025180	0.912
NATIVE	1	2.5472	0.8126	9.8252	0.0017	0.072962	12.772
ASIAN	1	-0.2588	0.4093	0.3998	0.5272	-0.007976	0.772
BLACK	1	-0.3660	0.1501	5.9443	0.0148	-0.029928	0.694
HISPANIC	1	0.3686	0.1765	4.3629	0.0367	0.025408	1.446
MCDPAY	1	-0.4339	0.1604	7.3191	0.0068	-0.037294	0.648
MCRPAY	1	-2.5911	0.5590	21.4814	0.0001	-0.690563	0.075
AMCRPAY	1	0.0399	0.00867	21.2346	0.0001	0.828548	1.041
MCRMGM	1	1.0686	0.1811	34.8148	0.0001	0.096695	2.911
OGVMTPAY	1	0.1121	0.2530	0.1962	0.6578	0.005593	1.119
SELFPAY	1	-0.3208	0.1626	3.8937	0.0485	-0.027540	0.726
FREECARE	1	-0.6451	0.2360	7.4734	0.0063	-0.036446	0.525
COMMCARE	1	1.1244	0.4625	5.9096	0.0151	0.226797	3.078
ACOMMCAR	1	-0.0210	0.00811	6.7321	0.0095	-0.241239	0.979

NONBMSA	1	-0.1678	0.0632	7.0409	0.0080	-0.037660	0.846
ADMIERRM	1	-1.3399	0.0512	684.9072	0.0001	-0.356629	0.262
ANTERIOR	1	0.1308	0.1717	0.5806	0.4461	0.031928	1.140
ATRIBLK	1	-0.5096	0.1747	8.5113	0.0035	-0.042183	0.601
CHF	1	-0.3737	0.0561	44.2872	0.0001	-0.100477	0.688
CHRLIVER	1	-1.2192	0.3318	13.5029	0.0002	-0.053348	0.295
CHRRENAL	1	-0.5145	0.1252	16.8897	0.0001	-0.064503	0.598
DIABETCM	1	-0.5174	0.1139	20.6329	0.0001	-0.062258	0.596
DIABETUN	1	-0.1037	0.0720	2.0781	0.1494	-0.019573	0.901
HYPER	1	0.0783	0.0530	2.1855	0.1393	0.020816	1.081
HYPO	1	-0.2731	0.0952	8.2381	0.0041	-0.041096	0.761
INFERIOR	1	0.2570	0.1728	2.2116	0.1370	0.061251	1.293
OTHCEREB	1	-0.3091	0.0542	32.5691	0.0001	-0.080923	0.734
LATECVA	1	1.5137	0.1342	127.1993	0.0001	0.167312	4.544
OTHVALVE	1	-0.3147	0.1085	8.4158	0.0037	-0.043616	0.730
PRIMALIG	1	-1.4725	0.2983	24.3721	0.0001	-0.074734	0.229
PULEDEMA	1	-0.1197	0.1299	0.8483	0.3570	-0.013375	0.887
SEIZURE	1	-0.7389	0.1908	15.0028	0.0001	-0.059002	0.478
SHOCK	1	-1.8601	0.6613	7.9108	0.0049	-0.056668	0.156
SITE_OTH	1	-0.9099	0.1981	21.0953	0.0001	-0.135361	0.403
SKNULCER	1	-1.2355	0.2978	17.2114	0.0001	-0.066956	0.291
SUBENDO	1	0.0564	0.1718	0.1078	0.7427	0.015368	1.058
COMBO4	1	0.2823	0.1350	4.3756	0.0365	0.030772	1.326
PRCABG	1	1.4955	0.4954	9.1119	0.0025	0.042271	4.462
GROPPE95	1	0.00563	0.1664	0.0011	0.9730	0.000691	1.006
NURSEBED	1	1.7406	0.0994	306.8870	0.0001	0.330002	5.701
TERTIARY	1	1.4824	0.0798	344.7757	0.0001	0.393243	4.403

Association of Predicted Probabilities and Observed Responses

Concordant = 89.9%	Somers' D = 0.799
Discordant = 10.0%	Gamma = 0.800
Tied = 0.1%	Tau-a = 0.375
(46292790 pairs)	c = 0.900

FULL PROCESS MODEL

The LOGISTIC Procedure

Data Set: WORK.FINAL1
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10833.966	.
SC	18612.543	11143.505	.
-2 LOG L	18602.993	10751.966	7851.027 with 40 DF (p=0.0001)
Score	.	.	6533.017 with 40 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.7413	0.7019	155.0792	0.0001	.	.
CAGE	1	0.2388	0.0217	120.5963	0.0001	1.779697	1.270
AGESQ	1	-0.00240	0.000186	166.2153	0.0001	-2.387747	0.998
FEMALE	1	-0.0878	0.0518	2.8726	0.0901	-0.024008	0.916
NATIVE	1	2.5377	0.8135	9.7307	0.0018	0.072689	12.650
ASIAN	1	-0.2546	0.4087	0.3881	0.5333	-0.007846	0.775
BLACK	1	-0.3575	0.1498	5.6961	0.0170	-0.029237	0.699
HISPANIC	1	0.3723	0.1765	4.4511	0.0349	0.025662	1.451
MCDPAY	1	-0.4384	0.1602	7.4866	0.0062	-0.037685	0.645
MCRPAY	1	-2.6047	0.5584	21.7569	0.0001	-0.694205	0.074
AMCRPAY	1	0.0401	0.00866	21.4883	0.0001	0.832561	1.041
MCRMGM	1	1.0682	0.1811	34.8070	0.0001	0.096665	2.910
OGVMTPAY	1	0.1084	0.2536	0.1829	0.6689	0.005412	1.115
SELFPAY	1	-0.3254	0.1626	4.0048	0.0454	-0.027933	0.722
FREECARE	1	-0.6462	0.2359	7.5032	0.0062	-0.036509	0.524
COMMCARE	1	1.1218	0.4626	5.8805	0.0153	0.226267	3.070
ACOMMCAR	1	-0.0210	0.00811	6.6924	0.0097	-0.240524	0.979

NONBMSA	1	-0.1698	0.0632	7.2271	0.0072	-0.038124	0.844
ADMIERRM	1	-1.3388	0.0512	684.5622	0.0001	-0.356351	0.262
ANTERIOR	1	0.1302	0.1713	0.5771	0.4474	0.031769	1.139
ATRIBLK	1	-0.5215	0.1742	8.9582	0.0028	-0.043172	0.594
CHF	1	-0.3905	0.0554	49.6196	0.0001	-0.105000	0.677
CHRLIVER	1	-1.2497	0.3310	14.2518	0.0002	-0.054681	0.287
CHRRENAL	1	-0.5338	0.1245	18.3992	0.0001	-0.066928	0.586
DIABETCM	1	-0.5043	0.1133	19.8134	0.0001	-0.060677	0.604
HYPO	1	-0.2801	0.0948	8.7345	0.0031	-0.042146	0.756
INFERIOR	1	0.2537	0.1724	2.1649	0.1412	0.060467	1.289
OTHCEREB	1	-0.3147	0.0540	33.9731	0.0001	-0.082390	0.730
LATECVA	1	1.5411	0.1328	134.6260	0.0001	0.170337	4.670
OTHVALVE	1	-0.3181	0.1084	8.6131	0.0033	-0.044094	0.728
PRIMALIG	1	-1.4860	0.2977	24.9161	0.0001	-0.075415	0.226
SEIZURE	1	-0.7459	0.1905	15.3337	0.0001	-0.059560	0.474
SHOCK	1	-1.9278	0.6598	8.5368	0.0035	-0.058730	0.145
SITE_OTH	1	-0.9166	0.1977	21.4946	0.0001	-0.136366	0.400
SKNULCER	1	-1.2483	0.2976	17.5998	0.0001	-0.067653	0.287
SUBENDO	1	0.0548	0.1715	0.1021	0.7493	0.014931	1.056
COMB04	1	0.2583	0.1310	3.8888	0.0486	0.028153	1.295
PRCABG	1	1.4997	0.4953	9.1690	0.0025	0.042390	4.480
GROPPE95	1	0.00514	0.1663	0.0010	0.9753	0.000631	1.005
NURSEBED	1	1.7402	0.0993	307.1011	0.0001	0.329928	5.699
TERTIARY	1	1.4854	0.0798	346.8881	0.0001	0.394045	4.417

Association of Predicted Probabilities and Observed Responses

Concordant	= 89.9%	Somers' D	= 0.799
Discordant	= 10.0%	Gamma	= 0.800
Tied	= 0.1%	Tau-a	= 0.375
(46292790 pairs)		c	= 0.900

APPENDIX I

FINAL PROCESS MODEL

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10860.562	.
SC	18612.543	11139.902	.
-2 LOG L	18602.993	10786.562	7816.431 with 36 DF (p=0.0001)
Score	.	.	6512.811 with 36 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.4123	0.6708	157.2462	0.0001	.	.
CAGE	1	0.2390	0.0221	117.1317	0.0001	1.780753	1.270
AGESQ	1	-0.00249	0.000196	160.9071	0.0001	-2.478831	0.998
FEMALE	1	-0.0872	0.0517	2.8416	0.0919	-0.023839	0.916
NATIVE	1	2.5383	0.8180	9.6281	0.0019	0.072706	12.658
ASIAN	1	-0.2241	0.4061	0.3046	0.5810	-0.006906	0.799
BLACK	1	-0.3695	0.1494	6.1169	0.0134	-0.030217	0.691
HISPANIC	1	0.3537	0.1762	4.0296	0.0447	0.024379	1.424
MCDPAY	1	-0.4147	0.1513	7.5086	0.0061	-0.035646	0.661
MCRPAY	1	-3.2040	0.5559	33.2226	0.0001	-0.839445	0.041
AMCRPAY	1	0.0520	0.00856	36.8801	0.0001	1.061118	1.053
OGVMTPAY	1	0.1728	0.2477	0.4864	0.4855	0.008622	1.189
UNINSUD	1	-0.4247	0.1313	10.4578	0.0012	-0.043306	0.654
NONBMSA	1	-0.1869	0.0626	8.9132	0.0028	-0.041953	0.830
ADMIERRM	1	-1.3416	0.0511	689.9828	0.0001	-0.357094	0.261
ANTERIOR	1	0.1166	0.1716	0.4621	0.4967	0.028464	1.124

ATRIBLK	1	-0.5313	0.1746	9.2637	0.0023	-0.043983	0.588
CHF	1	-0.3930	0.0554	50.3908	0.0001	-0.105667	0.675
CHRLIVER	1	-1.2584	0.3321	14.3577	0.0002	-0.055063	0.284
CHRRENAL	1	-0.5366	0.1245	18.5726	0.0001	-0.067278	0.585
DIABETCM	1	-0.4957	0.1130	19.2567	0.0001	-0.059639	0.609
HYPO	1	-0.2843	0.0945	9.0554	0.0026	-0.042774	0.753
INFERIOR	1	0.2333	0.1726	1.8272	0.1765	0.055624	1.263
OTHCEREB	1	-0.3199	0.0539	35.2093	0.0001	-0.083745	0.726
LATECVA	1	1.5281	0.1322	133.6665	0.0001	0.168905	4.610
OTHVALVE	1	-0.3292	0.1081	9.2712	0.0023	-0.045625	0.720
PRIMALIG	1	-1.4973	0.2993	25.0273	0.0001	-0.075989	0.224
SEIZURE	1	-0.7448	0.1903	15.3214	0.0001	-0.059480	0.475
SHOCK	1	-1.9593	0.6610	8.7869	0.0030	-0.059690	0.141
SITE_OTH	1	-0.9456	0.1978	22.8652	0.0001	-0.140676	0.388
SKNULCER	1	-1.2190	0.2976	16.7751	0.0001	-0.066062	0.296
SUBENDO	1	0.0342	0.1717	0.0396	0.8422	0.009312	1.035
COMB04	1	0.2465	0.1307	3.5570	0.0593	0.026864	1.280
PRCABG	1	1.4983	0.4943	9.1895	0.0024	0.042350	4.474
GROPPE95	1	0.0834	0.1659	0.2529	0.6150	0.010242	1.087
NURSEBED	1	1.7175	0.0987	302.6270	0.0001	0.325615	5.570
TERTIARY	1	1.4444	0.0793	331.5204	0.0001	0.383166	4.239

Association of Predicted Probabilities and Observed Responses

Concordant = 89.8%	Somers' D = 0.798
Discordant = 10.1%	Gamma = 0.798
Tied = 0.1%	Tau-a = 0.375
(46292790 pairs)	c = 0.899

APPENDIX J

FINAL PROCESS MODEL WITH PATIENTS OF INDEMNITY PLANS AS BASE GROUP

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10858.484	.
SC	18612.543	11152.924	.
-2 LOG L	18602.993	10780.484	7822.509 with 38 DF (p=0.0001)
Score	.	.	6517.623 with 38 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.8707	0.7094	156.3506	0.0001	.	.
CAGE	1	0.2471	0.0224	121.6501	0.0001	1.841648	1.280
AGESQ	1	-0.00248	0.000196	160.2844	0.0001	-2.472261	0.998
FEMALE	1	-0.0878	0.0518	2.8754	0.0899	-0.023987	0.916
NATIVE	1	2.5311	0.8125	9.7051	0.0018	0.072500	12.567
ASIAN	1	-0.2695	0.4072	0.4380	0.5081	-0.008305	0.764
BLACK	1	-0.3713	0.1496	6.1616	0.0131	-0.030364	0.690
HISPANIC	1	0.3566	0.1762	4.0956	0.0430	0.024580	1.428
MCDPAY	1	-0.4329	0.1600	7.3212	0.0068	-0.037212	0.649
MCRPAY	1	-2.7209	0.5954	20.8857	0.0001	-0.712893	0.066
AMCRPAY	1	0.0429	0.00931	21.2288	0.0001	0.875392	1.044
OGVMTPAY	1	0.1181	0.2530	0.2181	0.6405	0.005895	1.125
UNINSUD	1	-0.4189	0.1418	8.7307	0.0031	-0.042723	0.658
COMMCARE	1	1.0430	0.4689	4.9470	0.0261	0.210385	2.838
ACOMMCAR	1	-0.0196	0.00823	5.6819	0.0171	-0.224831	0.981

NONBMSA	1	-0.1857	0.0628	8.7296	0.0031	-0.041678	0.831
ADMIERRM	1	-1.3431	0.0511	690.8923	0.0001	-0.357486	0.261
ANTERIOR	1	0.1197	0.1714	0.4873	0.4851	0.029208	1.127
ATRIBLK	1	-0.5297	0.1745	9.2172	0.0024	-0.043852	0.589
CHF	1	-0.3924	0.0554	50.2228	0.0001	-0.105505	0.675
CHRLIVER	1	-1.2543	0.3316	14.3042	0.0002	-0.054883	0.285
CHRRENAL	1	-0.5404	0.1245	18.8445	0.0001	-0.067750	0.583
DIABETCM	1	-0.4979	0.1130	19.4142	0.0001	-0.059914	0.608
HYPO	1	-0.2846	0.0945	9.0748	0.0026	-0.042830	0.752
INFERIOR	1	0.2367	0.1725	1.8831	0.1700	0.056427	1.267
OTHCERE8	1	-0.3183	0.0539	34.8290	0.0001	-0.083327	0.727
LATECVA	1	1.5341	0.1324	134.1839	0.0001	0.169567	4.637
OTHVALVE	1	-0.3326	0.1082	9.4509	0.0021	-0.046099	0.717
PRIMALIG	1	-1.4911	0.2991	24.8462	0.0001	-0.075678	0.225
SEIZURE	1	-0.7515	0.1901	15.6295	0.0001	-0.060009	0.472
SHOCK	1	-1.9450	0.6599	8.6872	0.0032	-0.059253	0.143
SITE_OTH	1	-0.9421	0.1976	22.7344	0.0001	-0.140151	0.390
SKNULCER	1	-1.2259	0.2980	16.9195	0.0001	-0.066437	0.293
SUBENDO	1	0.0358	0.1716	0.0436	0.8346	0.009757	1.036
COM804	1	0.2453	0.1307	3.5241	0.0605	0.026737	1.278
PRCABG	1	1.5019	0.4953	9.1947	0.0024	0.042450	4.490
GROPPE95	1	0.0743	0.1660	0.2004	0.6544	0.009121	1.077
NURSE8ED	1	1.7188	0.0988	302.7293	0.0001	0.325861	5.578
TERTIARY	1	1.4456	0.0794	331.6284	0.0001	0.383488	4.244

Association of Predicted Probabilities and Observed Responses

Concordant	= 89.8%	Somers' D	= 0.798
Discordant	= 10.1%	Gamma	= 0.799
Tied	= 0.1%	Tau-a	= 0.375
(46292790 pairs)		c	= 0.899

FINAL PROCESS MODEL WITH PATIENTS OF MANAGED CARE AS BASE GROUP

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10859.221	.
SC	18612.543	11153.661	.
-2 LOG L	18602.993	10781.221	7821.772 with 38 DF (p=0.0001)
Score	.	.	6515.119 with 38 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

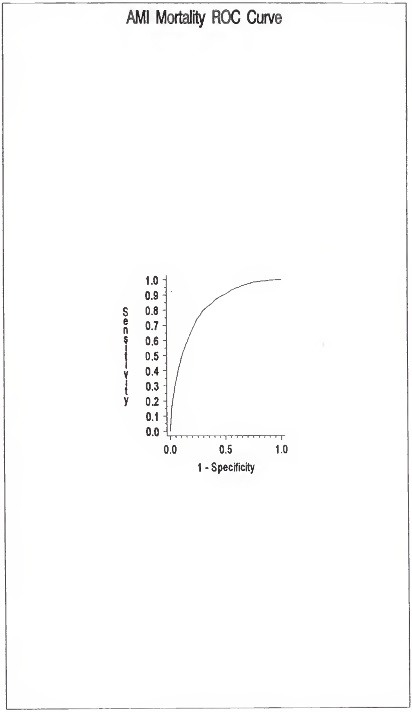
Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-8.1755	0.6787	145.1164	0.0001	.	.
CAGE	1	0.2354	0.0221	113.5558	0.0001	1.754460	1.265
AGESQ	1	-0.00251	0.000197	163.5911	0.0001	-2.502056	0.997
FEMALE	1	-0.0862	0.0518	2.7758	0.0957	-0.023573	0.917
NATIVE	1	2.5681	0.8206	9.7940	0.0018	0.073559	13.040
ASIAN	1	-0.2299	0.4068	0.3193	0.5720	-0.007083	0.795
BLACK	1	-0.3665	0.1495	6.0088	0.0142	-0.029971	0.693
HISPANIC	1	0.3511	0.1766	3.9528	0.0468	0.024200	1.421
MCDPAY	1	-0.3957	0.1558	6.4480	0.0111	-0.034015	0.673
MCRPAY	1	-3.5690	0.5848	37.2389	0.0001	-0.935075	0.028
AMCRPAY	1	0.0589	0.00913	41.5908	0.0001	1.201097	1.061
OGVMTPAY	1	0.2169	0.2509	0.7473	0.3873	0.010825	1.242
UNINSUD	1	-0.4228	0.1369	9.5369	0.0020	-0.043117	0.655
COMINDEM	1	-1.0596	0.5066	4.3737	0.0365	-0.187533	0.347

ACOMINDM	1	0.0198	0.00888	4.9889	0.0255	0.202736	1.020
NONBMSA	1	-0.1890	0.0628	9.0524	0.0026	-0.042434	0.828
ADMIERRM	1	-1.3412	0.0511	689.1355	0.0001	-0.356978	0.262
ANTERIOR	1	0.1223	0.1715	0.5083	0.4759	0.029845	1.130
ATRIBLK	1	-0.5371	0.1747	9.4558	0.0021	-0.044464	0.584
CHF	1	-0.3932	0.0554	50.4046	0.0001	-0.105734	0.675
CHRLIVER	1	-1.2693	0.3320	14.6136	0.0001	-0.055541	0.281
CHRRENAL	1	-0.5382	0.1245	18.6812	0.0001	-0.067474	0.584
DIABETCM	1	-0.4971	0.1130	19.3512	0.0001	-0.059806	0.608
HYPO	1	-0.2855	0.0945	9.1335	0.0025	-0.042964	0.752
INFERIOR	1	0.2388	0.1726	1.9142	0.1665	0.056921	1.270
OTHCEREB	1	-0.3208	0.0539	35.3738	0.0001	-0.083984	0.726
LATECVA	1	1.5326	0.1323	134.2369	0.0001	0.169393	4.630
OTHVALVE	1	-0.3284	0.1081	9.2272	0.0024	-0.045522	0.720
PRIMALIG	1	-1.4923	0.2993	24.8562	0.0001	-0.075735	0.225
SEIZURE	1	-0.7535	0.1903	15.6771	0.0001	-0.060172	0.471
SHOCK	1	-1.9507	0.6609	8.7123	0.0032	-0.059426	0.142
SITE_OTH	1	-0.9396	0.1976	22.6007	0.0001	-0.139775	0.391
SKNULCER	1	-1.2157	0.2978	16.6624	0.0001	-0.065886	0.296
SUBENDO	1	0.0377	0.1717	0.0482	0.8262	0.010269	1.038
COMB04	1	0.2407	0.1307	3.3890	0.0656	0.026231	1.272
PRCABG	1	1.5191	0.4954	9.4047	0.0022	0.042938	4.568
GROPPE95	1	0.0686	0.1661	0.1704	0.6798	0.008417	1.071
NURSEBED	1	1.7208	0.0988	303.3560	0.0001	0.326256	5.589
TERTIARY	1	1.4479	0.0794	332.4769	0.0001	0.384113	4.254

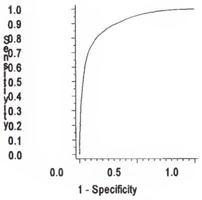
Association of Predicted Probabilities and Observed Responses

Concordant = 89.8%	Somers' D = 0.798
Discordant = 10.1%	Gamma = 0.799
Tied = 0.1%	Tau-a = 0.375
(46292790 pairs)	c = 0.899

APPENDIX K


AMI Mortality ROC Curve
Sensitivity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1 - Specificity

AMI Invasive Procedure Use ROC Curve



APPENDIX 1

FINAL PROCESS MODEL DROPPING THE INTERACTIVE VARIABLE OF AGE AND MEDICARE

The LOGISTIC Procedure

Data Set: WORK.F
Response Variable: INVASIVE
Response Levels: 2
Number of Observations: 14041
Link Function: Logit

Response Profile

Ordered Value	INVASIVE	Count
1	1	5290
2	0	8751

Model Fitting Information and Testing Global Null Hypothesis BETA=0

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	18604.993	10897.526	.
SC	18612.543	11169.317	.
-2 LOG L	18602.993	10825.526	7777.467 with 35 DF (p=0.0001)
Score	.	.	6494.218 with 35 DF (p=0.0001)

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	-6.4455	0.5763	125.0762	0.0001	.	.
CAGE	1	0.1544	0.0167	85.6404	0.0001	1.150625	1.167
AGESQ	1	-0.00162	0.000129	157.3393	0.0001	-1.610962	0.998
FEMALE	1	-0.0805	0.0516	2.4281	0.1192	-0.021999	0.923
NATIVE	1	2.5340	0.8104	9.7758	0.0018	0.072582	12.603
ASIAN	1	-0.2500	0.4032	0.3845	0.5352	-0.007704	0.779
BLACK	1	-0.4030	0.1489	7.3228	0.0068	-0.032952	0.668
HISPANIC	1	0.3105	0.1758	3.1176	0.0775	0.021401	1.364
MCDPAY	1	-0.4140	0.1503	7.5887	0.0059	-0.035583	0.661
MCRPAY	1	0.1513	0.0736	4.2288	0.0397	0.039653	1.163
OGVMTPAY	1	0.1212	0.2469	0.2410	0.6235	0.006049	1.129
UNINSUD	1	-0.4009	0.1302	9.4832	0.0021	-0.040884	0.670
NONBMSA	1	-0.1785	0.0625	8.1666	0.0043	-0.040070	0.837
ADMIERRM	1	-1.3467	0.0509	698.7050	0.0001	-0.358445	0.260
ANTERIOR	1	0.1189	0.1714	0.4817	0.4877	0.029026	1.126

ATRIBLK	1	-0.5284	0.1743	9.1859	0.0024	-0.043738	0.590
CHF	1	-0.3966	0.0553	51.4771	0.0001	-0.106641	0.673
CHRLIVER	1	-1.3396	0.3335	16.1389	0.0001	-0.058617	0.262
CHRRENAL	1	-0.5752	0.1245	21.3594	0.0001	-0.072114	0.563
DIABETCM	1	-0.5237	0.1130	21.4857	0.0001	-0.063012	0.592
HYPO	1	-0.2835	0.0943	9.0418	0.0026	-0.042651	0.753
INFERIOR	1	0.2389	0.1725	1.9191	0.1660	0.056948	1.270
OTHCEREB	1	-0.3222	0.0538	35.8260	0.0001	-0.084360	0.725
LATECVA	1	1.5072	0.1319	130.5925	0.0001	0.166594	4.514
OTHVALVE	1	-0.3271	0.1079	9.1915	0.0024	-0.045339	0.721
PRIMALIG	1	-1.5143	0.3006	25.3741	0.0001	-0.076856	0.220
SEIZURE	1	-0.7613	0.1902	16.0275	0.0001	-0.060797	0.467
SHOCK	1	-2.0090	0.6592	9.2882	0.0023	-0.061202	0.134
SITE_OTH	1	-0.9641	0.1976	23.8024	0.0001	-0.143420	0.381
SKNULCER	1	-1.2478	0.2979	17.5447	0.0001	-0.067624	0.287
SUBENDO	1	0.0341	0.1715	0.0396	0.8423	0.009298	1.035
COMBO4	1	0.2510	0.1300	3.7248	0.0536	0.027355	1.285
PRCABG	1	1.4337	0.4952	8.3819	0.0038	0.040525	4.194
GROPPE95	1	0.1123	0.1654	0.4612	0.4971	0.013790	1.119
NURSEBED	1	1.6998	0.0985	298.1122	0.0001	0.322275	5.473
TERTIARY	1	1.4297	0.0790	327.3302	0.0001	0.379269	4.177

Association of Predicted Probabilities and Observed Responses

Concordant = 89.7%	Somers' D = 0.796
Discordant = 10.1%	Gamma = 0.797
Tied = 0.1%	Tau-a = 0.374
(46292790 pairs)	c = 0.898

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